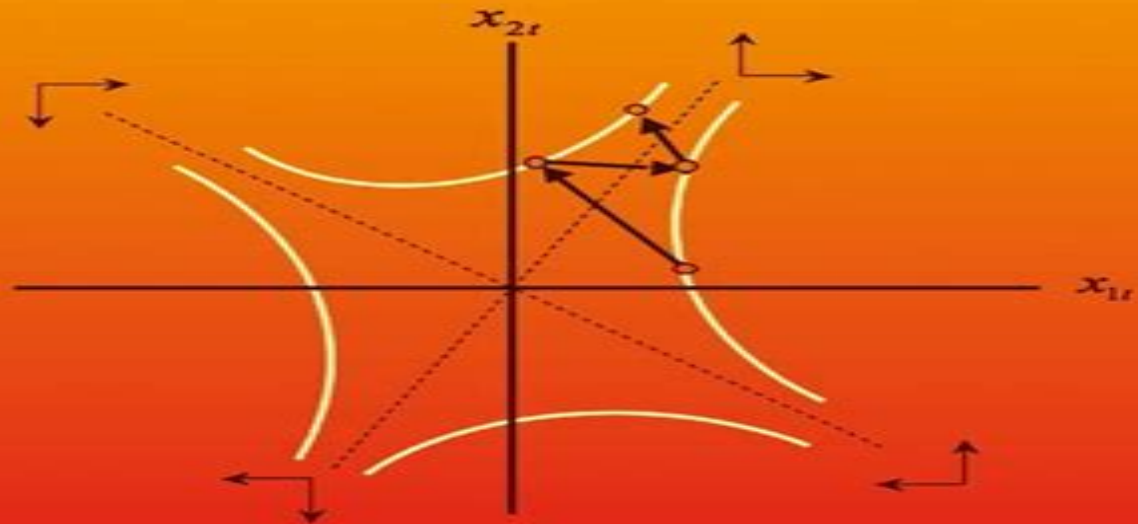


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# Discrete Dynamical Systems



# Discrete Dynamical Systems

**Jacques M. Bahi, Christophe Guyeux**



## **Discrete Dynamical Systems:**

*Discrete Dynamical Systems* James T. Sandefur, 1990 This textbook is an elementary introduction to the world of dynamical systems and Chaos Dynamical systems provide a mathematical means of modeling and analysing aspects of the changing world around us The aim of this ground breaking new text is to introduce the reader both to the wide variety of techniques used to study dynamical systems and to their many applications In particular investigation of dynamical systems leads to the important concepts of stability strange attractors Chaos and fractals *An Introduction to Dynamical Systems* Rex Clark Robinson, 2012 This book gives a mathematical treatment of the introduction to qualitative differential equations and discrete dynamical systems The treatment includes theoretical proofs methods of calculation and applications The two parts of the book continuous time of differential equations and discrete time of dynamical systems can be covered independently in one semester each or combined together into a year long course The material on differential equations introduces the qualitative or geometric approach through a treatment of linear systems in any dimensions There follows chapters where equilibria are the most important feature where scalar energy functions is the principal tool where periodic orbits appear and finally chaotic systems of differential equations The many different approaches are systematically introduced through examples and theorems The material on discrete dynamical systems starts with maps of one variable and proceeds to systems in higher dimensions The treatment starts with examples where the periodic points can be found explicitly and then introduces symbolic dynamics to analyze where they can be shown to exist but not given in explicit form Chaotic systems are presented both mathematically and more computationally using Lyapunov exponents With the one dimensional maps as models the multidimensional maps cover the same material in higher dimensions This higher dimensional material is less computational and more conceptual and theoretical The final chapter on fractals introduces various dimensions which is another computational tool for measuring the complexity of a system It also treats iterated function systems which give examples of complicated sets In the second edition of the book much of the material has been rewritten to clarify the presentation Also some new material has been included in both parts of the book This book can be used as a textbook for an advanced undergraduate course on ordinary differential equations and or dynamical systems Prerequisites are standard courses in calculus single variable and multivariable linear algebra and introductory differential equations Discrete Dynamical Systems Oded Galor, 2007-05-17 This book provides an introduction to discrete dynamical systems a framework of analysis that is commonly used in the fields of biology demography ecology economics engineering finance and physics The book characterizes the fundamental factors that govern the quantitative and qualitative trajectories of a variety of deterministic discrete dynamical systems providing solution methods for systems that can be solved analytically and methods of qualitative analysis for those systems that do not permit or necessitate an explicit solution The analysis focuses initially on the characterization of the factors that govern the evolution of state variables in the elementary

context of one dimensional first order linear autonomous systems The fundamental insights about the forces that affect the evolution of these elementary systems are subsequently generalized and the determinants of the trajectories of multi dimensional nonlinear higher order non autonomous dynamical systems are established Chapter 1 focuses on the analysis of the evolution of state variables in one dimensional first order autonomous systems It introduces a method of solution for these systems and it characterizes the trajectory of a state variable in relation to a steady state equilibrium of the system examining the local and global asymptotic stability of this steady state equilibrium The first part of the chapter characterizes the factors that determine the existence uniqueness and stability of a steady state equilibrium in the elementary context of one dimensional first order linear autonomous systems

*Discovering Discrete Dynamical Systems* Aimee Johnson, Kathleen Madden, Ayse Sahin, 2017-12-31 *Discovering Discrete Dynamical Systems* is a mathematics textbook designed for use in a student led inquiry based course for advanced mathematics majors Fourteen modules each with an opening exploration a short exposition and related exercises and a concluding project guide students to self discovery on topics such as fixed points and their classifications chaos and fractals Julia and Mandelbrot sets in the complex plane and symbolic dynamics Topics have been carefully chosen as a means for developing student persistence and skill in exploration conjecture and generalization while at the same time providing a coherent introduction to the fundamentals of discrete dynamical systems This book is written for undergraduate students with the prerequisites for a first analysis course and it can easily be used by any faculty member in a mathematics department regardless of area of expertise Each module starts with an exploration in which the students are asked an open ended question This allows the students to make discoveries which lead them to formulate the questions that will be addressed in the exposition and exercises of the module The exposition is brief and has been written with the intent that a student who has taken or is ready to take a course in analysis can read the material independently The exposition concludes with exercises which have been designed to both illustrate and explore in more depth the ideas covered in the exposition Each module concludes with a project in which students bring the ideas from the module to bear on a more challenging or in depth problem A section entitled To the Instructor includes suggestions on how to structure a course in order to realize the inquiry based intent of the book The book has also been used successfully as the basis for an independent study course and as a supplementary text for an analysis course with traditional content

**Discrete Dynamical Systems, Bifurcations and Chaos in Economics** Wei-Bin Zhang, 2006-01-05 This book is a unique blend of difference equations theory and its exciting applications to economics It deals with not only theory of linear and linearized difference equations but also nonlinear dynamical systems which have been widely applied to economic analysis in recent years It studies most important concepts and theorems in difference equations theory in a way that can be understood by anyone who has basic knowledge of calculus and linear algebra It contains well known applications and many recent developments in different fields of economics The book also simulates many models to illustrate paths of economic

dynamics A unique book concentrated on theory of discrete dynamical systems and its traditional as well as advanced applications to economics Mathematical definitions and theorems are introduced in a systematic and easily accessible way Examples are from almost all fields of economics technically proceeding from basic to advanced topics Lively illustrations with numerous figures Numerous simulation to see paths of economic dynamics Comprehensive treatment of the subject with a comprehensive and easily accessible approach An Introduction To Chaotic Dynamical Systems Robert L.

Devaney, 2021-11-28 There is an explosion of interest in dynamical systems in the mathematical community as well as in many areas of science The results have been truly exciting systems which once seemed completely intractable from an analytic point of view can now be understood in a geometric or qualitative sense rather easily Scientists and engineers realize the power and the beauty of the geometric and qualitative techniques These techniques apply to a number of important nonlinear problems ranging from physics and chemistry to ecology and economics Computer graphics have allowed us to view the dynamical behavior geometrically The appearance of incredibly beautiful and intricate objects such as the Mandelbrot set the Julia set and other fractals have really piqued interest in the field This text is aimed primarily at advanced undergraduate and beginning graduate students Throughout the author emphasizes the mathematical aspects of the theory of discrete dynamical systems not the many and diverse applications of this theory The field of dynamical systems and especially the study of chaotic systems has been hailed as one of the important breakthroughs in science in the past century and its importance continues to expand There is no question that the field is becoming more and more important in a variety of scientific disciplines New to this edition Greatly expanded coverage complex dynamics now in Chapter 2 The third chapter is now devoted to higher dimensional dynamical systems Chapters 2 and 3 are independent of one another New exercises have been added throughout **Advances in Discrete Dynamical Systems** Saber Elaydi, 2009 This volume contains the proceedings of talks presented at the 11th International Conference on Difference Equations and Applications ICDEA 2006 ICDEA 2006 was held on July 2006 in Kyoto at the 15th MSJ International Research Institute These proceedings comprise new results at the leading edge of many areas in difference equations and discrete dynamical systems and their various applications to the sciences engineering physics and economics **A First Course in Discrete Dynamical Systems** Richard A. Holmgren, 2012-09-05 Discrete dynamical systems are essentially iterated functions Given the ease with which computers can do iteration it is now possible for anyone with access to a personal computer to generate beautiful images whose roots lie in discrete dynamical systems Images of Mandelbrot and Julia sets abound in publications both mathematical and not The mathematics behind the pictures are beautiful in their own right and are the subject of this text The level of the presentation is suitable for advanced undergraduates with a year of calculus behind them Students in the author's courses using this material have come from numerous disciplines many have been majors in other disciplines who are taking mathematics courses out of general interest Concepts from calculus are reviewed as necessary Mathematica

programs that illustrate the dynamics and that will aid the student in doing the exercises are included in an appendix

**Discrete Dynamical Systems and Difference Equations with Mathematica** Mustafa R.S. Kulenovic, Orlando Merino, 2002-02-27 Following the work of Yorke and Li in 1975 the theory of discrete dynamical systems and difference equations developed rapidly The applications of difference equations also grew rapidly especially with the introduction of graphical interface software that can plot trajectories calculate Lyapunov exponents plot bifurcation diagrams and find ba

Difference Equations And Discrete Dynamical Systems - Proceedings Of The 9th International Conference Linda Allen, Bernd Aulbach, Saber N Elaydi, Robert Sacker, 2005-10-07 Difference Equations or Discrete Dynamical Systems is a diverse field which impacts almost every branch of pure and applied mathematics Not surprisingly the techniques that are developed vary just as broadly No more so is this variety reflected than at the prestigious annual International Conference on Difference Equations and Applications Organized under the auspices of the International Society of Difference Equations the Conferences have an international attendance and a wide coverage of topics The contributions from the conference collected in this volume invite the mathematical community to see a variety of problems and applications with one ingredient in common the Discrete Dynamical System Readers may also keep abreast of the many novel techniques and developments in the field The special emphasis of the meeting was on mathematical biology and accordingly about half of the articles are in the related areas of mathematical ecology and mathematical medicine

**Discrete Dynamical Systems and Chaotic Machines** Jacques M. Bahi, Christophe Gueyux, 2013-06-07 For computer scientists especially those in the security field the use of chaos has been limited to the computation of a small collection of famous but unsuitable maps that offer no explanation of why chaos is relevant in the considered contexts Discrete Dynamical Systems and Chaotic Machines Theory and Applications shows how to make finite machines such as computers neural networks and wireless sensor networks work chaotically as defined in a rigorous mathematical framework Taking into account that these machines must interact in the real world the authors share their research results on the behaviors of discrete dynamical systems and their use in computer science Covering both theoretical and practical aspects the book presents Key mathematical and physical ideas in chaos theory Computer science fundamentals clearly establishing that chaos properties can be satisfied by finite state machines Concrete applications of chaotic machines in computer security including pseudorandom number generators hash functions digital watermarking and steganography Concrete applications of chaotic machines in wireless sensor networks including secure data aggregation and video surveillance Until the authors recent research the practical implementation of the mathematical theory of chaos on finite machines raised several issues This self contained book illustrates how chaos theory enables the study of computer security problems such as steganalysis that otherwise could not be tackled It also explains how the theory reinforces existing cryptographically secure tools and schemes

*Analysis and Modelling of Discrete Dynamical Systems* Daniel Benest, Claude Froeschle, 1998-10-28 The theory of dynamical systems or mappings plays an

important role in various disciplines of modern physics including celestial mechanics and fluid mechanics This comprehensive introduction to the general study of mappings has particular emphasis on their applications to the dynamics of the solar system The book forms a bridge between continuous systems which are suited to analytical developments and to discrete systems which are suitable for numerical exploration Featuring chapters based on lectures delivered at the School on Discrete Dynamical Systems Aussois France February 1996 the book contains three parts Numerical Tools and Modelling Analytical Methods and Examples of Application It provides a single source of information that until now has been available only in widely dispersed journal articles **A First Course in Discrete Dynamical Systems** Richard A

Holmgren,1996-08-01 **Discrete Dynamical Models** Ernesto Salinelli,Franco Tomarelli,2014-06-11 This book provides an introduction to the analysis of discrete dynamical systems The content is presented by an unitary approach that blends the perspective of mathematical modeling together with the ones of several discipline as Mathematical Analysis Linear Algebra Numerical Analysis Systems Theory and Probability After a preliminary discussion of several models the main tools for the study of linear and non linear scalar dynamical systems are presented paying particular attention to the stability analysis Linear difference equations are studied in detail and an elementary introduction of Z and Discrete Fourier Transform is presented A whole chapter is devoted to the study of bifurcations and chaotic dynamics One step vector valued dynamical systems are the subject of three chapters where the reader can find the applications to positive systems Markov chains networks and search engines The book is addressed mainly to students in Mathematics Engineering Physics Chemistry Biology and Economics The exposition is self contained some appendices present prerequisites algorithms and suggestions for computer simulations The analysis of several examples is enriched by the proposition of many related exercises of increasing difficulty in the last chapter the detailed solution is given for most of them *An Introduction to Discrete Dynamical Systems and Their General Solutions* Frederico Oliveira-Pinto,2010 This book studies 1 D and 2 D general solutions of discrete and continuous analogue dynamical systems and identifies their intrinsic differences It starts by introducing discrete dynamical systems before comparing them to continuous analogue ones It studies in some depth their chaotic type solutions The 3rd edition is more comprehensive with greater emphasis on the stabilizing effect of harvesting fishing on oscillating dynamical systems on periodic solutions and on predator prey dynamic matters The book contains examples of applications to accounting pharmacology harvesting fishing strategies economic and population models and historical battles Introduction to Discrete Dynamical Systems and Chaos Mario Martelli,2011-11-01 A timely accessible introduction to the mathematics of chaos The past three decades have seen dramatic developments in the theory of dynamical systems particularly regarding the exploration of chaotic behavior Complex patterns of even simple processes arising in biology chemistry physics engineering economics and a host of other disciplines have been investigated explained and utilized Introduction to Discrete Dynamical Systems and Chaos makes these exciting and important ideas accessible to

students and scientists by assuming as a background only the standard undergraduate training in calculus and linear algebra. Chaos is introduced at the outset and is then incorporated as an integral part of the theory of discrete dynamical systems in one or more dimensions. Both phase space and parameter space analysis are developed with ample exercises; more than 100 figures and important practical examples such as the dynamics of atmospheric changes and neural networks. An appendix provides readers with clear guidelines on how to use Mathematica to explore discrete dynamical systems numerically. Selected programs can also be downloaded from a Wiley ftp site address in preface. Another appendix lists possible projects that can be assigned for classroom investigation. Based on the author's 1993 book but boasting at least 60% new revised and updated material, the present *Introduction to Discrete Dynamical Systems and Chaos* is a unique and extremely useful resource for all scientists interested in this active and intensely studied field.

**Geometric Methods for Discrete Dynamical Systems** Robert W. Easton, 1998. This book looks at dynamics as an iteration process where the output of a function is fed back as an input to determine the evolution of an initial state over time. The theory examines errors which arise from round off in numerical simulations from the inexactness of mathematical models used to describe physical processes and from the effects of external controls. The author provides an introduction accessible to beginning graduate students and emphasizing geometric aspects of the theory. Conley's ideas about rough orbits and chain recurrence play a central role in the treatment. The book will be a useful reference for mathematicians, scientists, and engineers studying this field and an ideal text for graduate courses in dynamical systems.

**Chaos in Discrete Dynamical Systems** Ralph Abraham, Laura Gardini, Christian Mira, 2013-06-29. Chaos Theory is a synonym for dynamical systems theory, a branch of mathematics. Dynamical systems come in three flavors: flows, continuous dynamical systems, cascades, discrete reversible dynamical systems, and semi-cascades, discrete irreversible dynamical systems. Flows and semi-cascades are the classical systems introduced by Poincaré a century ago and are the subject of the extensively illustrated book *Dynamics: The Geometry of Behavior* Addison Wesley 1992, authored by Ralph Abraham and Shaw. Semi-cascades also known as iterated function systems are a recent innovation and have been well studied only in one dimension, the simplest case, since about 1950. The two-dimensional case is the current frontier of research. And from the computer graphics of the leading researcher come astonishing views of the new landscape such as the Julia and Mandelbrot sets in the beautiful books by Heinz Otto Peigen and his co-workers. Now the new theory of critical curves developed by Mira and his students and Toulouse provide a unique opportunity to explain the basic concepts of the theory of chaos and bifurcations for discrete dynamical systems in two dimensions. The materials in the book and on the accompanying disc are not solely developed only with the researcher and professional in mind but also with consideration for the student. The book is replete with some 100 computer graphics to illustrate the material and the CD-ROM contains full color animations that are tied directly into the subject matter of the book itself. In addition, much of this material has also been class tested by the authors. The cross platform CD also contains a software program called ENDO which enables users



to create their own 2 D imagery with X Windows Maple scripts are provided which give the reader the option of working directly with the code from which the graphs in the book were

**Introduction to Mathematical Modeling Using Discrete Dynamical Systems** Frederick R. Marotto, 2005-09-01 Using discrete dynamical systems this book introduces powerful mathematical modeling techniques both standard analytical and modern computational to students in mathematics the natural sciences and the social sciences With minimal mathematical background students will quickly progress from the traditional study of exponential growth and decay that simple linear equations always exhibit to an investigation of recently discovered chaotic dynamics often associated with nonlinear systems A wide diversity of applications demonstrates the usefulness and relevance of topics that have often been viewed as excessively theoretical or abstract such as sequences limits linear algebra complex variables and more By taking advantage of discrete dynamical systems students will have the opportunity to experience some fascinating areas of mathematical discovery

**Difference Equations, Discrete Dynamical Systems and Applications** Saber Elaydi, Christian Pötzsche, Adina Luminița Sasu, 2019-06-29 The book presents the proceedings of the 23rd International Conference on Difference Equations and Applications ICDEA 2017 held at the West University of Timi oara Romania under the auspices of the International Society of Difference Equations ISDE July 24 28 2017 It includes new and significant contributions in the field of difference equations discrete dynamical systems and their applications in various sciences Disseminating recent studies and related results and promoting advances the book appeals to PhD students researchers educators and practitioners in the field

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