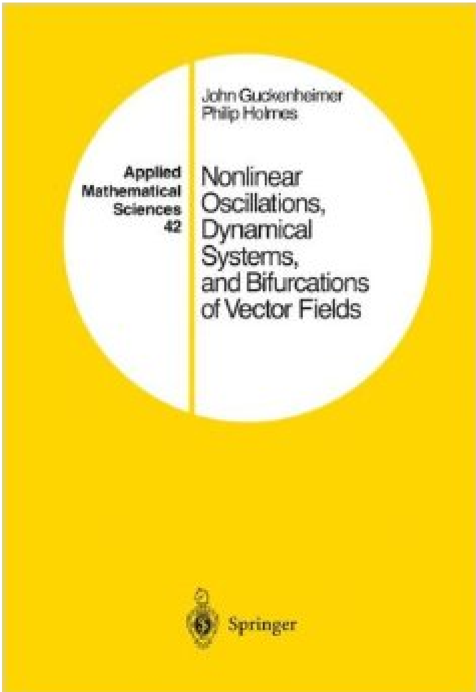
Nonlinear Oscillations, Dynamical Systems, And Bifurcations Of Vector Fields (Applied Mathematical Sciences)



Synopsis

An application of the techniques of dynamical systems and bifurcation theories to the study of nonlinear oscillations. Taking their cue from Poincare, the authors stress the geometrical and topological properties of solutions of differential equations and iterated maps. Numerous exercises, some of which require nontrivial algebraic manipulations and computer work, convey the important analytical underpinnings of problems in dynamical systems and help readers develop an intuitive feel for the properties involved.

Book Information

Series: Applied Mathematical Sciences (Book 42)
Hardcover: 462 pages
Publisher: Springer; 1st ed. 1983. Corr. 6th printing 2002 edition (February 8, 2002)
Language: English
ISBN-10: 0387908196
ISBN-13: 978-0387908199
Product Dimensions: 6.1 x 1.1 x 9.2 inches
Shipping Weight: 2 pounds (View shipping rates and policies)
Average Customer Review: 4.7 out of 5 starsÂ Â See all reviewsÂ (7 customer reviews)
Best Sellers Rank: #183,174 in Books (See Top 100 in Books)   #26 inÂ Books > Science & Math > Physics > Chaos Theory   #66 inÂ Books > Science & Math > Mathematics > Applied > Differential Equations   #107 inÂ Books > Science & Math > Mathematics > Mathematical Analysis

Customer Reviews

This book has been a continuing source of information and guidance for 18 years now. Students and researchers in many different fields have used this book due to its breadth and detail of coverage. The book does require a fairly advanced mathematical background, but the authors do include a glossary for the reader lacking this. Chapter one is an overview of differential equations and dynamical systems. All the concepts needed for a study of such systems are discussed in great detail and also very informally, stressing instead the understanding of the concepts, and not merely their definition. Some of the proofs of the main results, such as the Hartman-Grobman and the stable manifold theorems, are omitted however. This is followed in Chapter 2 by a very intuitive discussion of the van der Pols equation, Duffings equation, the Lorenz equations, and the bouncing ball. Numerical calculations are effectively employed to illustrate some of the main properties of the systems modeled by these equations. A taste of bifurcation theory follows in Chapter 3. Center manifolds are defined and many examples are given, but the proof of the center manifold theorem is omitted unfortunately. Normal forms and Hopf bifurcations are treated in detail. Averaging methods are discussed in Chapter 4, with part of the averaging theorem proved using a version of Gronwall's lemma. Several interesting examples of averaging are given, along with a discussion of to what extent the bifurcation properties of the averaged equations carry over to the original equations. Most importantly, this chapter discusses the Melnikov function, so very important in the study of small perturbations of dynamical systems with a hyperbolic fixed point. A full proof that simple zeros of the Melnikov function imply the transversal intersection of the stable and unstable manifolds is given. Chapter 5 moves on to results of a more purely mathematical nature, where symbolic dynamics and the Smale horseshoe map are discussed. The proofs of the stable manifold theorem and the Palis lambda lemma are, however, omitted. Markov partitions and the shadowing lemma are discussed also but the latter is not proven. The authors do however give a proof of the Smale-Birkhoff homoclinic theorem. A purely mathematical overview of attractors is given along with measure-theoretic (ergodic) properties of dynamical systems. The (local) bifurcation theory of Chapter 3 is extended to global bifurcations in the next chapter. A very detailed discussion of rotation numbers is given but the KAM theory is only briefly mentioned. The main emphasis is on 1-dimensional maps, the Lorentz system, and Silnikov theory. The authors give a very detailed treatment of wild hyperbolic sets. The book ends with a discussion of bifurcations from equilibrium points that have multiple degeneracies. The discussion is more motivated from a physical standpont than the last few chapters. But some interesting mathematical constructions are employed, namely the role of k-jets, which have fascinating connections with algebraic goemetry, via the "blowing-up" techniques. The concepts in the book have proven to have enduring value in the study of dynamical systems, and this book will no doubt continue to serve students and researchers in the years to come.

This book has clearly withstood the test of time in over 15 years of continuous publication. On my bookcase, it stands among my most treasured and well-worn classics of fluid mechanics and differential equations--Hirsch and Smale, Birkhoff and Rota, Chandrasekhar, Bachelor, Lamb, Landau and Lifschitz... It changed many of the unquestioned assumptions of many fields besides my own. It redefined the terms of many scientific debates. And, it changed my life.I obtained Guckenheimer and Holmes' classic when it first came out in 1983. It was so clear, concise and intellectually engaging that it inspired me to wonder whether the system of equations I was studying for my Ph.D. research at the time--the governing equations of thermal convection at infinite Prandtl number (which govern plate tectonics in the earth’s mantle)--might have a chaotic solution. Guckenheimer and Holmes outlined a clear methodology to find out the answer.My advisor at the University of Chicago thought not. Only steady solutions could be admitted in the absence of external forcing due to the lack of momentum transfer--this belief was widely held at the time, despite certain oscillatory solutions found by Fritz Busse (then at UCLA) and chaotic solutions found in certain limiting cases by Andrew Fowler at Oxford.In despair, I left my studies at Chicago to work as a Unix sysadmin at my undergraduate alma mater --Cornell, where (unbeknownst to me when I took the job) John Guckenheimer had just relocated from UCSC. Delighted to find him there, I sat in on his courses. Later, with his help, I wrote a proposal to NASA to support the completion of my thesis--with him and Donald Turcotte serving as my advisors.The 3-year fellowship was approved, and during this time I demonstrated and published that thermal convection at infinite Prandtl number--a condition that pervades many planetary interiors including our own--is indeed chaotic in the absence of external forcing.Prior to this, planetary convection codes primarily looked for steady state solutions. Since, numerical analysts in the field have upgraded to time-dependent models. The source of chaos at infinite Prandtle number I identified--the heat advection term--is now widely accepted as the source of what is now called "Thermal Turbulence" in planetary interiors.The defense at Chicago was quite an event. Since my new advisors were flown in from Ithaca, you might say my thesis--The Nonlinear Dynamics of Thermal Convection at Infinite Prandtl Number--passed with flying colors. Someone at Chicago might disagree, but his opinion is irrelevant.Demonstrating the many possible solutions to a single set of equations and showing how the choice of solution depends very sensitively on the rather poorly-constrained initial conditions of the earth--does render mantle modeling itself rather superfluous and indeed, scientifically suspect. However, many important professors who stayed in the field nonetheless continue to run their time-dependent mantle convection codes, and never cease to wonder at the fact that they all get different results. It’s rather amusing, really.When all that too has passed away, the truths so beautifully put forth in Guckenheimer and Holmes will remain. Like I said, it’s a classic. Furthermore, being number 42 in its series, it’s got to be the answer to the ultimate question of life, the universe and everything. Was for me, anyway.

This is a detailed book, though you do need to have some serious math background. The glossary doesn’t really make up for that. The discussion of dynamic systems and differential equations is good. Duffings, Lorenz, and van der Pols equations, and local and global bifurcation theory, are discussed. Bifurcations from equilibrium points with multiple degeneracies end the book. This is useful for studying dynamic systems.

The best of its kind

It’s ok.

For the moment it is "the" book on Dynamical Systems, through the world. Its first chapter is a good introduction on the mathematics needed to aboard the subject. The second introduces chaos, and the rest is for a good understanding of the newest and prolific science.

Guckenheimer is one of my favourite book in nonlinear science. Another absolute reference. This books deserved to be milestone in nonlinear dynamics.

Nonlinear Oscillations, Dynamical Systems, and Bifurcations of Vector Fields (Applied Mathematical Sciences) Entropy of Hidden Markov Processes and Connections to Dynamical Systems: Papers from the Banff International Research Station Workshop (London Mathematical Society Lecture Note Series) Illustrated Handbook of Cardiac Surgery (Applied Mathematical Sciences; 109) The Arithmetic of Dynamical Systems (Graduate Texts in Mathematics) Mrs. Fields Cookie Book: 100 Recipes from the Kitchen of Mrs. Fields Normal Modes and Localization in Nonlinear Systems Physics for Scientists and Engineers, Vol. 1: Mechanics, Oscillations and Waves, Thermodynamics (Physics for Scientists & Engineers, Chapters 1-21) Nonlinear Systems Ultracold Quantum Fields (Theoretical and Mathematical Physics) Mathematical Interest Theory (Mathematical Association of America Textbooks) Finite Fields, Coding Theory, and Advances in Communications and Computing (Lecture Notes in Pure and Applied Mathematics) Error-Correcting Codes and Finite Fields. Student Edition (Oxford Applied Mathematics and Computing Science Series) Error-Correcting Codes and Finite Fields (Oxford Applied Mathematics and Computing Science Series) The Global Dynamics of Cellular Automata: An Atlas of Basin of Attraction Fields of One-Dimensional Cellular Automata (Santa Fe Institute Studies in the Sciences of Complexity Reference Volumes) Dynamical Vision: ICCV 2005 and ECCV 2006 Workshops, WDV 2005 and WDV 2006, Beijing, China, October 21, 2005, Graz, Austria, May 13, 2006, Revised Papers (Lecture Notes in Computer Science) Sigma Delta Modulators: Nonlinear Decoding Algorithms and Stability Analysis (The Springer International Series in Engineering and Computer Science) Banach Space Theory: The Basis for Linear and Nonlinear Analysis (CMS Books in Mathematics) Linear and Nonlinear Programming (International Series in Operations Research & Management Science) Important Developments in Soliton Theory (Springer Series in Nonlinear Dynamics) College Mathematics for Business, Economics, Life Sciences, and Social Sciences (13th Edition)