Foundations Of Ergodic Theory Cambridge Studies I

This excellent 1981 treatment of the mathematical theory of entropy gives an accessible exposition its application to other fields. Recent findings in the computer sciences, discrete mathematics, formal logics and metamathematics have opened up a royal road for the investigation of undecidability and randomness in physics. A translation of these formal concepts yields a fresh look into diverse features of physical modelling such as quantum complementarity and the measurement problem, but also stipulates questions related to the necessity of the assumption of continua. Conversely, any computer may be perceived as a physical system: not only in the immediate sense of the physical properties of its hardware. Computers are a medium to virtual realities. The foreseeable importance of such virtual realities stimulates the investigation of an “ inner description ”, a “ virtual physics ” of these universes of computation. Indeed, one may consider our own universe as just one particular realisation of an enormous number of virtual realities, most of them awaiting discovery. One motive of this book is the recognition that what is often referred to as “ randomness ” in physics might actually be a signature of undecidability for systems whose evolution is computable on a step-by-step basis. To give a flavour of the type of questions envisaged: Consider an arbitrary algorithmic system which is computable on a step-by-step basis. Then it is in general impossible to specify a second algorithmic procedure, including itself, which, by experimental input-output analysis, is capable of finding the deterministic law of the first system. But even if such a law is specified beforehand, it is in general impossible to predict the system behaviour in the “ distant future ”. In other words: no “ speedup ” or “ computational shortcut ” is available. In this approach, classical paradoxes can be formally translated into no-go theorems concerning intrinsic physical perception. It is suggested that complementarity can be modelled by experiments on finite automata, where measurements of one observable of the automaton destroys the possibility to measure another observable of the same automaton and it vice versa. Besides undecidability, a great part of the book is dedicated to a formal definition of randomness and entropy measures based on algorithmic information theory. Contents:Algorithmic Physics: The Universe as a ComputerAlgorithmics and Recursive Function TheoryMechanism and DeterminismDiscrete PhysicsSource CodingLattice TheoryExtrinsic-Intrinsic ConceptAlgorithmic InformationComputational ComplexityUndecidabilityClassical ResultsComplementarityExtrinsic IndeterminismIntrinsic IndeterminismWeak Physical ChaosRandomnessRandomness in MathematicsRandom Fractals and 1/f NoiseChaotic Systems are Optimal Analogues of ThemselvesQuantum ChaosAlgorithmic EntropyEpilogue: Afterthoughts, Speculations and Metaphysics Readership: Physicists, computer scientists and mathematicians. keywords:Undecidability;Randomness;Algorithmic Information Theory;Automaton Logic;Quantum Logic;Recursive Function Theory;Discrete Physics;Lattice Theory;Intrinsic Perception;Halting ProblemCristian Calude

This textbook is a self-contained and easy-to-read introduction to ergodic theory and the theory of dynamical systems, with a particular emphasis on chaotic dynamics. This book contains a broad selection of topics and explores the fundamental ideas of the subject. Starting with basic notions such as ergodicity, mixing, and isomorphisms of dynamical systems, the book then focuses on

several chaotic transformations with hyperbolic dynamics, before moving on to topics such as entropy, information theory, ergodic decomposition and measurable partitions. Detailed explanations are accompanied by numerous examples, including interval maps, Bernoulli shifts, toral endomorphisms, geodesic flow on negatively curved manifolds, Morse-Smale systems, rational maps on the Riemann sphere and strange attractors. Ergodic Theory and Dynamical Systems will appeal to graduate students as well as researchers looking for an introduction to the subject. While gentle on the beginning student, the book also contains a number of comments for the more advanced reader.

This is a mathematically rigorous introduction to fractals which emphasizes examples and fundamental ideas. Building up from basic techniques of geometric measure theory and probability, central topics such as Hausdorff dimension, self-similar sets and Brownian motion are introduced, as are more specialized topics, including Kakeya sets, capacity, percolation on trees and the traveling salesman theorem. The broad range of techniques presented enables key ideas to be highlighted, without the distraction of excessive technicalities. The authors incorporate some novel proofs which are simpler than those available elsewhere. Where possible, chapters are designed to be read independently so the book can be used to teach a variety of courses, with the clear structure offering students an accessible route into the topic.

Fractals in Probability and Analysis

Philosophy of Physics

Modern Theory of Dynamical Systems: A Tribute to Dmitry Victorovich Anosov

Randomness and Undecidability in Physics

with a view towards Number Theory

This is a graduate text in differentiable dynamical systems. It focuses on structural stability and hyperbolicity, a topic that is central to the fie Starting with the basic concepts of dynamical systems, analyzing the historic systems of the Smale horseshoe, Anosov toral automorphism the solenoid attractor, the book develops the hyperbolic theory first for hyperbolic fixed points and then for general hyperbolic sets. The problems of stable manifolds, structural stability, and shadowing property are investigated, which lead to a highlight of the book, the ?-stabi theorem of Smale. While the content is rather standard, a key objective of the book is to present a thorough treatment for some tough mate that has remained an obstacle to teaching and learning the subject matter. The treatment is straightforward and hence could be particularly suitable for self-study. Selected solutions are available electronically for instructors only. Please send email to textbooks@ams.org for more information.

Contributed by close colleagues, friends, and former students of Floris Takens, Global Analysis of Dynamical Systems is a liber amicorum dedicated to Takens for his 60th birthday. The first chapter is a reproduction of Takens's 1974 paper "Forced oscillators and bifurcations" th was previously available only as a preprint of the University of Utrecht. Among other important results, it contains the unfolding of what is no known as the Bogdanov-Takens bifurcation. The remaining chapters cover topics as diverse as bifurcation theory, Hamiltonian mechanics, homoclinic bifurcations, routes to chaos, ergodic theory, renormalization theory, and time series analysis. In its entirety, the book bears witn

to the influence of Takens on the modern theory of dynamical systems and its applications. This book is a must-read for anyone interested this active and exciting field.

Probability theory is nowadays applied in a huge variety of fields including physics, engineering, biology, economics and the social sciences This book is a modern, lively and rigorous account which has Doob's theory of martingales in discrete time as its main theme. It proves important results such as Kolmogorov's Strong Law of Large Numbers and the Three-Series Theorem by martingale techniques, and the Central Limit Theorem via the use of characteristic functions. A distinguishing feature is its determination to keep the probability flowing at a nice tempo. It achieves this by being selective rather than encyclopaedic, presenting only what is essential to understand the fundamentals it assumes certain key results from measure theory in the main text. These measure-theoretic results are proved in full in appendices, so th book is completely self-contained. The book is written for students, not for researchers, and has evolved through several years of class test Exercises play a vital rôle. Interesting and challenging problems, some with hints, consolidate what has already been learnt, and provide motivation to discover more of the subject than can be covered in a single introduction.

This text is a rigorous introduction to ergodic theory, developing the machinery of conditional measures and expectations, mixing, and recurrence. Beginning by developing the basics of ergodic theory and progressing to describe some recent applications to number theory, t book goes beyond the standard texts in this topic. Applications include Weyl's polynomial equidistribution theorem, the ergodic proof of Szemeredi's theorem, the connection between the continued fraction map and the modular surface, and a proof of the equidistribution of horocycle orbits. Ergodic Theory with a view towards Number Theory will appeal to mathematicians with some standard background in measure theory and functional analysis. No background in ergodic theory or Lie theory is assumed, and a number of exercises and hints to problems are included, making this the perfect companion for graduate students and researchers in ergodic theory, homogenous dynamics number theory.

The Mathematical Foundations of Mixing

Advances in Applied Mechanics

Dynamical Systems and Ergodic Theory

Elements of Causal Inference

Ergodic Dynamics

Modern developments in representation theory rely heavily on homological methods. This book for advanced graduate students and researchers introduces these methods from their foundations up and discusses several landmark results that illustrate their power and beauty. Categorical foundations include abelian and derived categories, with an emphasis on localisation, spectra, and purity. The representation theoretic focus is on module categories of Artin algebras, with discussions of the representation theory of finite groups and finite quivers. Also covered are Gorenstein and quasi-hereditary algebras, including Schur algebras, which model polynomial representations of general linear groups, and the Morita theory of derived categories via tilting objects. The final part is devoted to a

systematic introduction to the theory of purity for locally finitely presented categories, covering pure-injectives, definable subcategories, and Ziegler spectra. With its clear, detailed exposition of important topics in modern representation theory, many of which were unavailable in one volume until now, it deserves a place in every representation theorist's library.

The first edition of this single volume on the theory of probability has become a highly-praised standard reference for many areas of probability theory. Chapters from the first edition have been revised and corrected, and this edition contains four new chapters. New material covered includes multivariate and ratio ergodic theorems, shift coupling, Palm distributions, Harris recurrence, invariant measures, and strong and weak ergodicity.

Rich with examples and applications, this textbook provides a coherent and self-contained introduction to ergodic theory, suitable for a variety of one- or two-semester courses. The authors' clear and fluent exposition helps the reader to grasp quickly the most important ideas of the theory, and their use of concrete examples illustrates these ideas and puts the results into perspective. The book requires few prerequisites, with background material supplied in the appendix. The first four chapters cover elementary material suitable for undergraduate students – invariance, recurrence and ergodicity – as well as some of the main examples. The authors then gradually build up to more sophisticated topics, including correlations, equivalent systems, entropy, the variational principle and thermodynamical formalism. The 400 exercises increase in difficulty through the text and test the reader's understanding of the whole theory. Hints and solutions are provided at the end of the book.

This book provides an introduction to the mathematical and algorithmic foundations of data science, including machine learning, high-dimensional geometry, and analysis of large networks. Topics include the counterintuitive nature of data in high dimensions, important linear algebraic techniques such as singular value decomposition, the theory of random walks and Markov chains, the fundamentals of and important algorithms for machine learning, algorithms and analysis for clustering, probabilistic models for large networks, representation learning including topic modelling and non-negative matrix factorization, wavelets and compressed sensing. Important probabilistic techniques are developed including the law of large numbers, tail inequalities, analysis of random projections, generalization guarantees in machine learning, and moment methods for analysis of phase transitions in large random graphs. Additionally, important structural and complexity measures are discussed such as matrix norms and VC-dimension. This book is suitable for both undergraduate and graduate courses in the design and analysis of algorithms for data.

Ergodic Theory, Hyperbolic Dynamics and Dimension Theory

Global Analysis of Dynamical Systems

Introduction to the Modern Theory of Dynamical Systems

Festschrift dedicated to Floris Takens for his 60th birthday

Information Theory, Inference and Learning Algorithms

A textbook on projective geometry that emphasises applications in modern information and communication science.
This book is about the basis of mathematical reasoning both in pure mathematics itself (particularly algebra and topology) and in computer science (how and what it means to prove correctness of programs). It contains original material and original developments of standard material, so it is also for professional researchers, but as it deliberately transcends disciplinary boundaries and challenges many established attitudes to the foundations of mathematics, the reader is expected to be open minded about these things.
This book focuses on the most important questions of philosophy of physics, offering a sufficiently concise and clear treatment of the issues to lead the interested reader through the sometimes labyrinthian paths taken by the central debates.
This classic text offers a clear exposition of modern probability theory.
Homological Theory of Representations
From Theory to Algorithms
From Basic Theory to Applications
Practical Foundations of Mathematics
Foundations of Ergodic Theory

Research monograph on set theory by two of the world's leading researchers.

Mathematics of Complexity and Dynamical Systems is an authoritative reference to the basic tools and concepts of complexity, systems theory, and dynamical systems from the perspective of pure and applied mathematics. Complex systems are systems that comprise many interacting parts with the ability to generate a new quality of collective behavior through self-organization, e.g. the spontaneous formation of temporal, spatial or functional structures. These systems are often characterized by extreme sensitivity to initial conditions as well as emergent behavior that are not readily predictable or even completely deterministic. The more than 100 entries in this wide-ranging, single source work provide a comprehensive explication of the theory and applications of mathematical complexity, covering ergodic theory, fractals and multifractals, dynamical systems, perturbation theory, solitons, systems and control theory, and related topics. Mathematics of Complexity and Dynamical Systems is an essential reference for all those interested in mathematical complexity, from undergraduate and graduate students up through professional researchers.

This book shows how densities arise in simple deterministic systems. There has been explosive growth in interest in physical, biological and economic systems that can be profitably studied using densities. Due to the inaccessibility of the mathematical literature there has been little diffusion of the applicable mathematics into the study of these 'chaotic' systems. This book will help to bridge that gap. The authors give a unified treatment of a variety of mathematical systems generating densities, ranging from one-dimensional discrete time transformations through continuous time systems described by integro-partial

differential equations. They have drawn examples from many scientific fields to illustrate the utility of the techniques presented. The book assumes a knowledge of advanced calculus and differential equations, but basic concepts from measure theory, ergodic theory, the geometry of manifolds, partial differential equations, probability theory and Markov processes, and stochastic integrals and differential equations are introduced as needed.

This important new book introduces, analyzes and takes forward a post-Keynesian theory of the firm. It makes a vital contribution to the conceptualisation of uncertainty that is consistent with the methodological presuppositions of Post Keynesian economics. The author attempts to make a positive contribution to the development of Post Keynesian economics by refuting allegations of incoherence, detailing some of the salient implications of a transmutable conception of economic processes and then starting to explore what this means for how Post Keynesians conceptualise uncertainty. The book argues that the Post Keynesian distinctive view of time, understood as a non-deterministic open systems process, is a core and defining characteristic which is linked to its theoretical discussion of money and the principle of effective demand. Covering areas such as the coherence of Post Keynesianism, the future of Post Keynesian economics and Keynesian methodological debates, this book is useful reading for all Post Keynesian scholars with a strong interest in economic methodology and the philosophical underpinnings of economics.

Quasiconformal Surgery in Holomorphic Dynamics

Probability with Martingales

The Descriptive Set Theory of Polish Group Actions

Foundations of Data Science

CIRM Jean-Morlet Chair, Fall 2019

This book establishes the foundations needed to realize the ultimate goals for artificial intelligence, such as autonomy and trustworthiness. Aimed at scientists, researchers, technologists, practitioners, and students, it brings together contributions offering the basics, the challenges and the state-of-the-art on trusted autonomous systems in a single volume. The book is structured in three parts, with chapters written by eminent researchers and outstanding practitioners and users in the field. The first part covers foundational artificial intelligence technologies, while the second part covers philosophical, practical and technological perspectives on trust. Lastly, the third part presents advanced topics necessary to create future trusted autonomous systems. The book augments theory with real-world applications including cyber security, defence and space.

This textbook provides a broad introduction to the fields of dynamical systems and ergodic theory. Motivated by examples throughout, the author offers readers an approachable entry-point to the dynamics of ergodic systems. Modern and classical applications complement the theory on topics ranging from financial fraud to virus dynamics, offering numerous avenues for further inquiry. Starting with several simple examples of dynamical systems, the book begins by establishing the basics of measurable

dynamical systems, attractors, and the ergodic theorems. From here, chapters are modular and can be selected according to interest. Highlights include the Perron–Frobenius theorem, which is presented with proof and applications that include Google PageRank. An in-depth exploration of invariant measures includes ratio sets and type III measurable dynamical systems using the von Neumann factor classification. Topological and measure theoretic entropy are illustrated and compared in detail, with an algorithmic application of entropy used to study the papillomavirus genome. A chapter on complex dynamics introduces Julia sets and proves their ergodicity for certain maps. Cellular automata are explored as a series of case studies in one and two dimensions, including Conway's Game of Life and latent infections of HIV. Other chapters discuss mixing properties, shift spaces, and toral automorphisms. Ergodic Dynamics unifies topics across ergodic theory, topological dynamics, complex dynamics, and dynamical systems, offering an accessible introduction to the area. Readers across pure and applied mathematics will appreciate the rich illustration of the theory through examples, real-world connections, and vivid color graphics. A solid grounding in measure theory, topology, and complex analysis is assumed; appendices provide a brief review of the essentials from measure theory, functional analysis, and probability.

Mixing processes occur in many technological and natural applications, with length and time scales ranging from the very small to the very large. The diversity of problems can give rise to a diversity of approaches. Are there concepts that are central to all of them? Are there tools that allow for prediction and quantification? The authors show how a variety of flows in very different settings possess the characteristic of streamline crossing. This notion can be placed on firm mathematical footing via Linked Twist Maps (LTMs), which is the central organizing principle of this book. The authors discuss the definition and construction of LTMs, provide examples of specific mixers that can be analyzed in the LTM framework and introduce a number of mathematical techniques which are then brought to bear on the problem of fluid mixing. In a final chapter, they present a number of open problems and new directions.

Over the last two decades, the dimension theory of dynamical systems has progressively developed into an independent and extremely active field of research. The main aim of this volume is to offer a unified, self-contained introduction to the interplay of these three main areas of research: ergodic theory, hyperbolic dynamics, and dimension theory. It starts with the basic notions of the first two topics and ends with a sufficiently high-level introduction to the third. Furthermore, it includes an introduction to the thermodynamic formalism, which is an important tool in dimension theory. The volume is primarily intended for graduate students interested in dynamical systems, as well as researchers in other areas who wish to learn about ergodic theory, thermodynamic formalism, or dimension theory of hyperbolic dynamics at an intermediate level in a sufficiently detailed manner. In particular, it can be used as a basis for graduate courses on any of these three subjects. The text can also be used for self-study: it is self-contained, and with the exception of some well-known basic facts from other areas, all statements include detailed proofs.

From Foundations to Applications
Essays in Exploration
Real Analysis and Probability
Mathematical Theory of Entropy
The Linked Twist Map as a Paradigm in Applications: Micro to Macro, Fluids to Solids

The Advances in Applied Mechanics book series draws together recent significant advances in various topics in applied mechanics. Published since 1948, Advances in Applied Mechanics aims to provide authoritative review articles on topics in the mechanical sciences, primarily of interest to scientists and engineers working in the various branches of mechanics, but also of interest to the many who use the results of investigations in mechanics in various application areas, such as aerospace, chemical, civil, environmental, mechanical and nuclear engineering. Highlights classical and modern areas of mechanics that are ready for review Provides comprehensive coverage of the field in question

A First Course in Ergodic Theory provides readers with an introductory course in Ergodic Theory. This textbook has been developed from the authors' own notes on the subject, which they have been teaching since the 1990s. Over the years they have added topics, theorems, examples and explanations from various sources. The result is a book that is easy to teach from and easy to learn from — designed to require only minimal prerequisites. Features Suitable for readers with only a basic knowledge of measure theory, some topology and a very basic knowledge of functional analysis Perfect as the primary textbook for a course in Ergodic Theory Examples are described and are studied in detail when new properties are presented.

The beginning graduate student in homotopy theory is confronted with a vast literature on spectra that is scattered across books, articles and decades. There is much folklore but very few easy entry points. This comprehensive introduction to stable homotopy theory changes that. It presents the foundations of the subject together in one place for the first time, from the motivating phenomena to the modern theory, at a level suitable for those with only a first course in algebraic topology. Starting from stable homotopy groups and (co)homology theories, the authors study the most important categories of spectra and the stable homotopy category, before moving on to computational aspects and more advanced topics such as monoidal structures, localisations and chromatic homotopy theory. The appendix containing essential facts on model categories, the numerous examples and the suggestions for further reading make this a

friendly introduction to an often daunting subject.
A comprehensive introduction to quasiconformal surgery in holomorphic dynamics. Contains a wide variety of applications and illustrations.
Ergodic Theory and Dynamical Systems
A First Course in Ergodic Theory
Foundations of Modern Probability

Mathematics of Complexity and Dynamical Systems

Essentially a self-contained text giving an introduction to topological dynamics and ergodic theory.
A short introduction ideal for students learning category theory for the first time.
Table of contents
A self-contained comprehensive introduction to the mathematical theory of dynamical systems for students and researchers in mathematics, science and engineering.
Projective Geometry
Foundations of Convex Geometry
Thermodynamic Formalism
Transcendental Dynamics and Complex Analysis
Ergodic Theory

In honour of Noel Baker, a leading exponent of transcendental complex dynamics, this book describes the state of the art in this subject.
This volume arose from a semester at CIRM-Luminy on “Thermodynamic Formalism: Applications to Probability, Geometry and Fractals” which brought together leading experts in the area to discuss topical problems and recent progress. It includes a number of surveys intended to make the field more accessible to younger mathematicians and scientists wishing to learn more about the area. Thermodynamic formalism has been a powerful tool in ergodic theory and dynamical system and its applications to other topics, particularly Riemannian geometry (especially in negative curvature), statistical properties of dynamical systems and fractal geometry. This work will be of value both to graduate students and more senior researchers interested in either learning about the main ideas and themes in thermodynamic formalism, and research themes which are at forefront of research in this area.
Introduces machine learning and its algorithmic paradigms, explaining the principles behind automated learning approaches and the considerations underlying their usage.

This volume is a tribute to one of the founders of modern theory of dynamical systems, the late Dmitry Victorovich Anosov. It contains both original papers and surveys, written by some distinguished experts in dynamics, which are related to important themes of Anosov's work, as well as broadly interpreted further crucial developments in the theory of dynamical systems that followed Anosov's original work. Also included is an article by A. Katok that presents Anosov's scientific biography and a picture of the early development of hyperbolicity theory in its various incarnations, complete and partial, uniform and nonuniform.

Foundations of Trusted Autonomy

Philosophy Of Physics

The 'Uncertain' Foundations of Post Keynesian Economics

Foundations and Learning Algorithms

Probabilistic Properties of Deterministic Systems

This book on the foundations of Euclidean geometry aims to present the subject from the point of view of present day mathematics, taking advantage of all the developments since the appearance of Hilbert's classic work. Here real affine space is characterised by a small number of axioms involving points and line segments making the treatment self-contained and thorough, many results being established under weaker hypotheses than usual. The treatment should be totally accessible for final year undergraduates and graduate students, and can also serve as an introduction to other areas of mathematics such as matroids and antimatroids, combinatorial convexity, the theory of polytopes, projective geometry and functional analysis.

Self-contained introductory textbook suitable for a variety of one- or two-semester courses. Rich with examples, applications and exercises.

The ambition of this volume is twofold: to provide a comprehensive overview of the field and to serve as an indispensable reference work for anyone who wants to work in it. For example, any philosopher who hopes to make a contribution to the topic of the classical-quantum correspondence will have to begin by consulting Klaas Landsman's chapter. The organization of this volume, as well as the choice of topics, is based on the conviction that the important problems in the philosophy of physics arise from studying the foundations of the fundamental theories of physics. It follows that there is no sharp line to be drawn between philosophy of physics and physics itself. Some of the best work in the philosophy of physics is being done by physicists, as witnessed by the fact that several of the contributors to the volume are theoretical physicists: viz., Ellis, Emch, Harvey, Landsman, Rovelli, 't Hooft, the last of whom is a Nobel laureate. Key features - Definitive discussions of the philosophical implications of modern physics - Masterly expositions of the fundamental theories of modern physics - Covers all three main pillars of modern physics: relativity theory, quantum theory, and thermal physics - Covers the new sciences grown

from these theories: for example, cosmology from relativity theory; and quantum information and quantum computing, from quantum theory - Contains special Chapters that address crucial topics that arise in several different theories, such as symmetry and determinism - Written by very distinguished theoretical physicists, including a Nobel Laureate, as well as by philosophers - Definitive discussions of the philosophical implications of modern physics - Masterly expositions of the fundamental theories of modern physics - Covers all three main pillars of modern physics: relativity theory, quantum theory, and thermal physics - Covers the new sciences that have grown from these theories: for example, cosmology from relativity theory; and quantum information and quantum computing, from quantum theory - Contains special Chapters that address crucial topics that arise in several different theories, such as symmetry and determinism - Written by very distinguished theoretical physicists, including a Nobel Laureate, as well as by philosophers

A concise and self-contained introduction to causal inference, increasingly important in data science and machine learning. The mathematization of causality is a relatively recent development, and has become increasingly important in data science and machine learning. This book offers a self-contained and concise introduction to causal models and how to learn them from data. After explaining the need for causal models and discussing some of the principles underlying causal inference, the book teaches readers how to use causal models: how to compute intervention distributions, how to infer causal models from observational and interventional data, and how causal ideas could be exploited for classical machine learning problems. All of these topics are discussed first in terms of two variables and then in the more general multivariate case. The bivariate case turns out to be a particularly hard problem for causal learning because there are no conditional independences as used by classical methods for solving multivariate cases. The authors consider analyzing statistical asymmetries between cause and effect to be highly instructive, and they report on their decade of intensive research into this problem. The book is accessible to readers with a background in machine learning or statistics, and can be used in graduate courses or as a reference for researchers. The text includes code snippets that can be copied and pasted, exercises, and an appendix with a summary of the most important technical concepts.

Foundations of Stable Homotopy Theory

Basic Category Theory

Differentiable Dynamical Systems

Understanding Machine Learning