The entropy concept in probability theory. 2. On the fundamental theorems of information theory
This latest addition to the successful Network Biology series presents current methods for determining the entropy of networks, making it the first to cover the recently established Quantitative Graph Theory. An excellent international team of editors and contributors provides an up-to-date outlook for the field, covering a broad range of graph entropy-related concepts and methods. The topics range from analyzing mathematical properties of methods right up to applying them in real-life areas. Filling a gap in the contemporary literature this is an invaluable reference for a number of disciplines, including mathematicians, computer scientists, computational biologists, and structural chemists.

Concentration of Measure Inequalities in Information Theory, Communications, and Coding focuses on some of the key modern mathematical tools that are used for the derivation of concentration inequalities, on their links to information theory, and on their various applications to communications and coding.

Scientists are, all the time, in a struggle with uncertainty which is always a threat to a trustworthy scientific knowledge. A very simple and natural idea, to defeat uncertainty, is that of enclosing uncertain measured values in real closed intervals. On the basis of this idea, interval arithmetic is constructed. The idea of calculating with intervals is not completely new in mathematics: the concept has been known since Archimedes, who used guaranteed lower and upper bounds to compute his constant Pi. Interval arithmetic is now a broad field in which rigorous mathematics is associated with scientific computing. This connection makes it possible to solve uncertainty problems that cannot be efficiently solved by floating-point arithmetic. Today, application areas of interval methods include electrical engineering, control theory, remote sensing, experimental and computational physics, chaotic systems, celestial mechanics, signal processing, computer graphics, robotics, and computer-assisted proofs. The purpose of this book is to be a concise but informative introduction to the theories of
interval arithmetic as well as to some of their computational and scientific applications. Editorial Reviews "This new book by Hend Dawood is a fresh introduction to some of the basics of interval computation. It stops short of discussing the more complicated subdivision methods for converging to ranges of values, however it provides a bit of perspective about complex interval arithmetic, constraint intervals, and modal intervals, and it does go into the design of hardware operations for interval arithmetic, which is something still to be done by computer manufacturers." - Ramon E. Moore, (The Founder of Interval Computations) Professor Emeritus of Computer and Information Science, Department of Mathematics, The Ohio State University, Columbus, U.S.A. "A popular math-oriented introduction to interval computations and its applications. This short book contains an explanation of the need for interval computations, a brief history of interval computations, and main interval computation techniques. It also provides an impressive list of main practical applications of interval techniques." - Vladik Kreinovich, (International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems) Professor of Computer Science, University of Texas at El Paso, El Paso, Texas, U.S.A. "I am delighted to see one more Egyptian citizen re-entering the field of interval mathematics invented in this very country thousands years ago." - Marek W. Gutowski, Institute of Physics, Polish Academy of Sciences, Warszawa, Poland

This monograph provides a mathematical foundation to the theory of quantum information and computation, with applications to various open systems including nano and bio systems. It includes introductory material on algorithm, functional analysis, probability theory, information theory, quantum mechanics and quantum field theory. Apart from standard material on quantum information like quantum algorithm and teleportation, the authors discuss findings on the theory of entropy in C*-dynamical systems, space-time dependence of quantum entangled states, entangling operators, adaptive dynamics, relativistic quantum information, and a new paradigm for quantum computation beyond the usual quantum Turing machine. Also, some important applications of information theory to genetics and life sciences, as well as recent experimental and theoretical discoveries in quantum
This book provides the reader with the mathematical framework required to fully explore the potential of small quantum information processing devices. As decoherence will continue to limit their size, it is essential to master the conceptual tools which make such investigations possible. A strong emphasis is given to information measures that are essential for the study of devices of finite size, including Rényi entropies and smooth entropies. The presentation is self-contained and includes rigorous and concise proofs of the most important properties of these measures. The first chapters will introduce the formalism of quantum mechanics, with particular emphasis on norms and metrics for quantum states. This is necessary to explore quantum generalizations of Rényi divergence and conditional entropy, information measures that lie at the core of information theory. The smooth entropy framework is discussed next and provides a natural means to lift many arguments from information theory to the quantum setting. Finally selected applications of the theory to statistics and cryptography are discussed. The book is aimed at graduate students in Physics and Information Theory. Mathematical fluency is necessary, but no prior knowledge of quantum theory is required.

Introducing many innovations in content and methods, this book involves the foundations, basic concepts, and fundamental results of probability theory. Geared toward readers seeking a firm basis for study of mathematical statistics or information theory, it also covers the mathematical notions of experiments and independence. 1970 edition.

A valuable teaching aid. Provides relevant background material, many examples and clear solutions to problems taken from real exam papers.

The first book devoted exclusively to quantitative graph theory, Quantitative Graph Theory: Mathematical Foundations and Applications presents and demonstrates existing and novel methods for analyzing graphs quantitatively. Incorporating interdisciplinary knowledge from graph theory, information theory, measurement theory, and statistical techniques, this book covers a wide range of quantitative-
graph theoretical concepts and methods, including those pertaining to real and random graphs such as: Comparative approaches (graph similarity or distance) Graph measures to characterize graphs quantitatively. Applications of graph measures in social network analysis and other disciplines. Metrical properties of graphs and measures. Mathematical properties of quantitative methods or measures in graph theory. Network complexity measures and other topological indices. Quantitative approaches to graphs using machine learning (e.g., clustering) Graph measures and statistics. Information-theoretic methods to analyze graphs quantitatively (e.g., entropy). Through its broad coverage, Quantitative Graph Theory: Mathematical Foundations and Applications fills a gap in the contemporary literature of discrete and applied mathematics, computer science, systems biology, and related disciplines. It is intended for researchers as well as graduate and advanced undergraduate students in the fields of mathematics, computer science, mathematical chemistry, cheminformatics, physics, bioinformatics, and systems biology.

Mathematical Foundations of Quantum Theory is a collection of papers presented at the 1977 conference on the Mathematical Foundations of Quantum Theory, held in New Orleans. The contributors present their topics from a wide variety of backgrounds and specialization, but all shared a common interest in answering quantum issues. Organized into 20 chapters, this book's opening chapters establish a sound mathematical basis for quantum theory and a mode of observation in the double slit experiment. This book then describes the Lorentz particle system and other mathematical structures with which fundamental quantum theory must deal, and then some unsolved problems in the quantum logic approach to the foundations of quantum mechanics are considered. Considerable chapters cover topics on manuals and logics for quantum mechanics. This book also examines the problems in quantum logic, and then presents examples of their interpretation and relevance to nonclassical logic and statistics. The accommodation of conventional Fermi-Dirac and Bose-Einstein statistics in quantum mechanics or quantum field theory is illustrated. The final chapters of the book present a system of axioms for nonrelativistic quantum mechanics, with particular emphasis on the role of density operators as
states. Specific connections of this theory with other formulations of quantum theory are also considered. These chapters also deal with the determination of the state of an elementary quantum mechanical system by the associated position and momentum distribution. This book is of value to physicists, mathematicians, and researchers who are interested in quantum theory.

In nonparametric and high-dimensional statistical models, the classical Gauss–Fisher–Le Cam theory of the optimality of maximum likelihood estimators and Bayesian posterior inference does not apply, and new foundations and ideas have been developed in the past several decades. This book gives a coherent account of the statistical theory in infinite-dimensional parameter spaces. The mathematical foundations include self-contained 'mini-courses' on the theory of Gaussian and empirical processes, approximation and wavelet theory, and the basic theory of function spaces. The theory of statistical inference in such models - hypothesis testing, estimation and confidence sets - is presented within the minimax paradigm of decision theory. This includes the basic theory of convolution kernel and projection estimation, but also Bayesian nonparametrics and nonparametric maximum likelihood estimation. In a final chapter the theory of adaptive inference in nonparametric models is developed, including Lepski's method, wavelet thresholding, and adaptive inference for self-similar functions. Winner of the 2017 PROSE Award for Mathematics.

Quantum Information Theory and the Foundations of Quantum Mechanics is a conceptual analysis of one the most prominent and exciting new areas of physics, providing the first full-length philosophical treatment of quantum information theory and the questions it raises for our understanding of the quantum world. Beginning from a careful, revisionary, analysis of the concepts of information in the everyday and classical information-theory settings, Christopher G. Timpson argues for an ontologically deflationary account of the nature of quantum information. Against what many have supposed, quantum information can be clearly defined (it is not a primitive or vague notion) but it is not part of the material contents of the world. Timpson's account sheds light on the nature of nonlocality.
and information flow in the presence of entanglement and, in particular, dissolves puzzles surrounding the remarkable process of quantum teleportation. In addition it permits a clear view of what the ontological and methodological lessons provided by quantum information theory are; lessons which bear on the gripping question of what role a concept like information has to play in fundamental physics. Topics discussed include the slogan 'Information is Physical', the prospects for an informational immaterialism (the view that information rather than matter might fundamentally constitute the world), and the status of the Church-Turing hypothesis in light of quantum computation. With a clear grasp of the concept of information in hand, Timpson turns his attention to the pressing question of whether advances in quantum information theory pave the way for the resolution of the traditional conceptual problems of quantum mechanics: the deep problems which loom over measurement, nonlocality and the general nature of quantum ontology. He marks out a number of common pitfalls to be avoided before analysing in detail some concrete proposals, including the radical quantum Bayesian programme of Caves, Fuchs, and Schack. One central moral which is drawn is that, for all the interest that the quantum information-inspired approaches hold, no cheap resolutions to the traditional problems of quantum mechanics are to be had.

This text shows that insights in quantum physics can be obtained by exploring the mathematical structure of quantum mechanics. It presents the theory of Hermitian operators and Hilbert spaces, providing the framework for transformation theory, and using th

This informal introduction provides a fresh perspective on isomorphism theory, which is the branch of ergodic theory that explores the conditions under which two measure preserving systems are essentially equivalent. It contains a primer in basic measure theory, proofs of fundamental ergodic theorems, and material on entropy, martingales, Bernoulli processes, and various varieties of mixing. Original proofs of classic theorems - including the Shannon–McMillan–Breiman theorem, the Krieger finite generator theorem, and the Ornstein isomorphism theorem - are presented by degrees, together with helpful hints that
encourage the reader to develop the proofs on their own. Hundreds of exercises and open problems are also included, making this an ideal text for graduate courses. Professionals needing a quick review, or seeking a different perspective on the subject, will also value this book.

This comprehensive guide, by pioneers in the field, brings together, for the first time, everything a new researcher, graduate student or industry practitioner needs to get started in molecular communication. Written with accessibility in mind, it requires little background knowledge, and provides a detailed introduction to the relevant aspects of biology and information theory, as well as coverage of practical systems. The authors start by describing biological nanomachines, the basics of biological molecular communication and the microorganisms that use it. They then proceed to engineered molecular communication and the molecular communication paradigm, with mathematical models of various types of molecular communication and a description of the information and communication theory of molecular communication. Finally, the practical aspects of designing molecular communication systems are presented, including a review of the key applications. Ideal for engineers and biologists looking to get up to speed on the current practice in this growing field.

In this highly readable book, H.S. Green, a former student of Max Born and well known as an author in physics and in the philosophy of science, presents a timely analysis of theoretical physics and related fundamental problems.

This book offers a comprehensive and consistent mathematical approach to information retrieval (IR) without which no implementation is possible, and sheds an entirely new light upon the structure of IR models. It contains the descriptions of all IR models in a unified formal style and language, along with examples for each, thus offering a comprehensive overview of them. The book also creates mathematical foundations and a consistent mathematical theory (including all mathematical results achieved so far) of IR as a stand-alone mathematical discipline, which thus can be read and taught
This book applies methods from nonlinear dynamics to problems in neuroscience. It uses modern mathematical approaches to understand patterns of neuronal activity seen in experiments and models of neuronal behavior. The intended audience is researchers interested in applying mathematics to important problems in neuroscience, and neuroscientists who would like to understand how to create models, as well as the mathematical and computational methods for analyzing them. The authors take a very broad approach and use many different methods to solve and understand complex models of neurons and circuits. They explain and combine numerical, analytical, dynamical systems and perturbation methods to produce a modern approach to the types of model equations that arise in neuroscience. There are extensive chapters on the role of noise, multiple time scales and spatial interactions in generating complex activity patterns found in experiments. The early chapters require little more than basic calculus and some elementary differential equations and can form the core of a computational neuroscience course. Later chapters can be used as a basis for a graduate class and as a source for current research in mathematical neuroscience. The book contains a large number of illustrations, chapter summaries and hundreds of exercises which are motivated by issues that arise in biology, and involve both computation and analysis. Bard Ermentrout is Professor of Computational Biology and Professor of Mathematics at the University of Pittsburgh. David Terman is Professor of Mathematics at the Ohio State University.

This graduate textbook provides a unified view of quantum information theory. Clearly explaining the necessary mathematical basis, it merges
key topics from both information-theoretic and quantum-mechanical viewpoints and provides lucid explanations of the basic results. Thanks to this unified approach, it makes accessible such advanced topics in quantum communication as quantum teleportation, superdense coding, quantum state transmission (quantum error-correction) and quantum encryption. Since the publication of the preceding book Quantum Information: An Introduction, there have been tremendous strides in the field of quantum information. In particular, the following topics—all of which are addressed here—made significant advances: quantum state discrimination, quantum channel capacity, bipartite and multipartite entanglement, security analysis on quantum communication, reverse Shannon theorem and uncertainty relation.

With regard to the analysis of quantum security, the present book employs an improved method for the evaluation of leaked information and identifies a remarkable relation between quantum security and quantum coherence. Taken together, these two improvements allow a better analysis of quantum state transmission. In addition, various types of the newly discovered uncertainty relation are explained. Presenting a wealth of new developments, the book introduces readers to the latest advances and challenges in quantum information. To aid in understanding, each chapter is accompanied by a set of exercises and solutions.

Suitable for both senior undergraduate and graduate students, this is a self-contained book dealing with the classical theory of the partial differential equations through a modern approach; requiring minimal previous knowledge. It represents the solutions to three important equations of mathematical physics—Laplace and Poisson equations, Heat or diffusion equation, and wave equations in one and more space dimensions. Keen readers will benefit from more advanced topics and many references cited at the end of each chapter. In addition, the book covers advanced topics such as Conservation Laws and Hamilton-Jacobi Equation. Numerous real-life applications are interspersed throughout the book to retain readers' interest.

First comprehensive introduction to information theory explores the work of Shannon, McMillan, Feinstein, and Khinchin. Topics include
"To design future networks that are worthy of society's trust, we must put the 'discipline' of computer networking on a much stronger foundation. This book rises above the considerable minutiae of today's networking technologies to emphasize the long-standing mathematical underpinnings of the field." - Professor Jennifer Rexford, Department of Computer Science, Princeton University

"This book is exactly the one I have been waiting for the last couple of years. Recently, I decided most students were already very familiar with the way the net works but were not being taught the fundamentals—the math. This book contains the knowledge for people who will create and understand future communications systems." - Professor Jon Crowcroft, The Computer Laboratory, University of Cambridge

The Essential Mathematical Principles Required to Design, Implement, or Evaluate Advanced Computer Networks

Students, researchers, and professionals in computer networking require a firm conceptual understanding of its foundations. Mathematical Foundations of Computer Networking provides an intuitive yet rigorous introduction to these essential mathematical principles and techniques. Assuming a basic grasp of calculus, this book offers sufficient detail to serve as the only reference many readers will need. Each concept is described in four ways: intuitively; using appropriate mathematical notation; with a numerical example carefully chosen for its relevance to networking; and with a numerical exercise for the reader. The first part of the text presents basic concepts, and the second part introduces four theories in a progression that has been designed to gradually deepen readers' understanding. Within each part, chapters are as self-contained as possible. The first part covers probability; statistics; linear algebra; optimization; and signals, systems, and transforms. Topics range from Bayesian networks to hypothesis testing, and eigenvalue computation to Fourier transforms. These preliminary chapters establish a basis for the four theories covered in the second part of the book: queueing theory, game theory, control theory, and information theory. The second part also demonstrates how mathematical concepts can be applied to issues
such as contention for limited resources, and the optimization of network responsiveness, stability, and throughput.

Mathematical Foundations of Computer Science, Volume I is the first of two volumes presenting topics from mathematics (mostly discrete mathematics) which have proven relevant and useful to computer science. This volume treats basic topics, mostly of a set-theoretical nature (sets, functions and relations, partially ordered sets, induction, enumerability, and diagonalization) and illustrates the usefulness of mathematical ideas by presenting applications to computer science. Readers will find useful applications in algorithms, databases, semantics of programming languages, formal languages, theory of computation, and program verification. The material is treated in a straightforward, systematic, and rigorous manner. The volume is organized by mathematical area, making the material easily accessible to the upper-undergraduate students in mathematics as well as in computer science and each chapter contains a large number of exercises. The volume can be used as a textbook, but it will also be useful to researchers and professionals who want a thorough presentation of the mathematical tools they need in a single source. In addition, the book can be used effectively as supplementary reading material in computer science courses, particularly those courses which involve the semantics of programming languages, formal languages and automata, and logic programming.

Phase space, ergodic problems, central limit theorem, dispersion and distribution of sum functions. Chapters include Geometry and Kinematics of the Phase Space; Ergodic Problem; Reduction to the Problem of the Theory of Probability; Application of the Central Limit Theorem; Ideal Monatomic Gas; The Foundation of Thermodynamics; and more.

In order best exploit the incredible quantities of data being generated in most diverse disciplines data sciences increasingly gain worldwide importance. The book gives the mathematical foundations to handle data properly. It introduces basics and functionalities of the R programming language which has become the indispensable tool for
data sciences. Thus it delivers the reader the skills needed to build own tool kits of a modern data scientist.

Graduate-level study approaches mathematical foundations of three-dimensional elasticity using modern differential geometry and functional analysis. It presents a classical subject in a modern setting, with examples of newer mathematical contributions. 1983 edition.

Mathematical logic is a branch of mathematics that takes axiom systems and mathematical proofs as its objects of study. This book shows how it can also provide a foundation for the development of information science and technology. The first five chapters systematically present the core topics of classical mathematical logic, including the syntax and models of first-order languages, formal inference systems, computability and representability, and Gödel’s theorems. The last five chapters present extensions and developments of classical mathematical logic, particularly the concepts of version sequences of formal theories and their limits, the system of revision calculus, proschemes (formal descriptions of proof methods and strategies) and their properties, and the theory of inductive inference. All of these themes contribute to a formal theory of axiomatization and its application to the process of developing information technology and scientific theories. The book also describes the paradigm of three kinds of language environments for theories and it presents the basic properties required of a meta-language environment. Finally, the book brings these themes together by describing a workflow for scientific research in the information era in which formal methods, interactive software and human invention are all used to their advantage. This book represents a valuable reference for graduate and undergraduate students and researchers in mathematics, information science and technology, and other relevant areas of natural sciences. Its first five chapters serve as an undergraduate text in mathematical logic and the last five chapters are addressed to graduate students in relevant disciplines.

Scientific knowledge grows at a phenomenal pace—but few books have had as lasting an impact or played as important a role in our modern
world as the Mathematical Theory of Communication, published originally as a paper on communication theory more than fifty years ago. Republished in book form shortly thereafter, it has since gone through four hardcover and sixteen paperback printings. It is a revolutionary work, astounding in its foresight and contemporaneity. The University of Illinois Press is pleased and honored to issue this commemorative reprinting of a classic.

First comprehensive introduction to information theory explores the work of Shannon, McMillan, Feinstein, and Khinchin. Topics include the entropy concept in probability theory, fundamental theorems, and other subjects. 1957 edition.

Mathematical Foundations for Signal Processing, Communications, and Networking describes mathematical concepts and results important in the design, analysis, and optimization of signal processing algorithms, modern communication systems, and networks. Helping readers master key techniques and comprehend the current research literature, the book offers a comprehensive overview of methods and applications from linear algebra, numerical analysis, statistics, probability, stochastic processes, and optimization. From basic transforms to Monte Carlo simulation to linear programming, the text covers a broad range of mathematical techniques essential to understanding the concepts and results in signal processing, telecommunications, and networking. Along with discussing mathematical theory, each self-contained chapter presents examples that illustrate the use of various mathematical concepts to solve different applications. Each chapter also includes a set of homework exercises and readings for additional study. This text helps readers understand fundamental and advanced results as well as recent research trends in the interrelated fields of signal processing, telecommunications, and networking. It provides all the necessary mathematical background to prepare students for more advanced courses and train specialists working in these areas.

Behind the familiar surfaces of the telephone, radio, and television lies
a sophisticated and intriguing body of knowledge known as information theory. This is the theory that has permeated the rapid development of all sorts of communication, from color television to the clear transmission of photographs from the vicinity of Jupiter. Even more revolutionary progress is expected in the future. To give a solid introduction to this burgeoning field, J. R. Pierce has revised his well-received 1961 study of information theory for an up-to-date second edition. Beginning with the origins of the field, Dr. Pierce follows the brilliant formulations of Claude Shannon and describes such aspects of the subject as encoding and binary digits, entropy, language and meaning, efficient encoding, and the noisy channel. He then goes beyond the strict confines of the topic to explore the ways in which information theory relates to physics, cybernetics, psychology, and art. Mathematical formulas are introduced at the appropriate points for the benefit of serious students. A glossary of terms and an appendix on mathematical notation are provided to help the less mathematically sophisticated. J. R. Pierce worked for many years at the Bell Telephone Laboratories, where he became Director of Research in Communications Principles. He is currently affiliated with the engineering department of the California Institute of Technology. While his background is impeccable, Dr. Pierce also possesses an engaging writing style that makes his book all the more welcome. An Introduction to Information Theory continues to be the most impressive non-technical account available and a fascinating introduction to the subject for laymen. "An uncommonly good study. . . . Pierce's volume presents the most satisfying discussion to be found."? Scientific American.

Books on information theory and coding have proliferated over the last few years, but few succeed in covering the fundamentals without losing students in mathematical abstraction. Even fewer build the essential theoretical framework when presenting algorithms and implementation details of modern coding systems. Without abandoning the theoret

This book gives a concise presentation of the mathematical foundations of Game Theory, with an emphasis on strategic analysis linked to information and dynamics. It is largely self-contained, with all of the key tools and concepts defined in the text. Combining the basics of
Game Theory, such as value existence theorems in zero-sum games and equilibrium existence theorems for non-zero-sum games, with a selection of important and more recent topics such as the equilibrium manifold and learning dynamics, the book quickly takes the reader close to the state of the art. Applications to economics, biology, and learning are included, and the exercises, which often contain noteworthy results, provide an important complement to the text. Based on lectures given in Paris over several years, this textbook will be useful for rigorous, up-to-date courses on the subject. A part from an interest in strategic thinking and a taste for mathematical formalism, the only prerequisite for reading the book is a solid knowledge of mathematics at the undergraduate level, including basic analysis, linear algebra, and probability.


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