Quantum Computing Since Democritus

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Programming Quantum Computers Eric R. Johnston 2019-07-03 Quantum computers are set to kick-start a second computing revolution in an exciting and intriguing way. Learning to program a Quantum Processing Unit (QPU) is not only fun and exciting, but it's a way to get your foot in the door. Like learning any kind of programming, the best way to proceed is by getting your hands dirty and diving into code. This practical book uses publicly available quantum computing engines, clever notation, and a programmer’s mindset to get you started. You'll be able to build up the intuition, skills, and tools needed to start writing quantum programs and solve problems that you care about.

Quantum Computing: An Applied Approach Jack D. Hidary 2021-10-31 This book integrates the foundations of quantum computing with a hands-on coding approach to this emerging field; it is the first to bring these elements together in an updated manner. This work is suitable for both academic coursework and corporate technical training. The second edition includes extensive updates and revisions, both to textual content and to the code. Sections have been added on quantum machine learning, quantum error correction, Dirac notation and more. This new edition benefits from the input of the many faculty, students, corporate engineering teams, and independent readers who have used the first edition. This volume comprises three books under one cover: Part I outlines the necessary foundations of quantum computing and quantum circuits. Part II walks through the canon of quantum computing algorithms and provides code on a range of quantum computing methods in current use. Part III covers the mathematical toolkit required to master quantum computing. Additional resources include a table of operators and circuit elements and a companion GitHub site providing code and updates. Jack D. Hidary is a research scientist in quantum computing and in AI at Alphabet X, formerly Google X.

Quantum Information Theory Mark M. Wilde 2017-02-06 Developing many of the major, exciting, pre- and post-millennium developments from the ground up, this book is an ideal entry point for graduate students into quantum information theory. Significant attention is given to quantum mechanics for quantum information theory, and careful studies of the important protocols of teleportation, superdense coding, and entanglement distribution are presented. In this new edition, readers can expect to find over 100 pages of new material, including detailed discussions of Bell's theorem, the CHSH game, Tsirelson's theorem, the axiomatic approach to quantum channels, the definition of the diamond norm and its interpretation, and a proof of the Choi–Kraus theorem. Discussion of the importance of the quantum dynamic capacity formula has been completely revised, and many new exercises and references have

been added. This new edition will be welcomed by the upcoming generation of quantum information theorists and the already established community of classical information theorists.

Quantum Computing for Computer Scientists Noson S. Yanofsky 2008-08-11 The multidisciplinary field of quantum computing strives to exploit some of the uncanny aspects of quantum mechanics to expand our computational horizons. Quantum Computing for Computer Scientists takes readers on a tour of this fascinating area of cutting-edge research. Written in an accessible yet rigorous fashion, this book employs ideas and techniques familiar to every student of computer science. The reader is not expected to have any advanced mathematics or physics background. After presenting the necessary prerequisites, the material is organized to look at different aspects of quantum computing from the specific standpoint of computer science. There are chapters on computer architecture, algorithms, programming languages, theoretical computer science, cryptography, information theory, and hardware. The text has step-by-step examples, more than two hundred exercises with solutions, and programming drills that bring the ideas of quantum computing alive for today's computer science students and researchers.

Inadequate Equilibria (Draft Version) Eliezer Yudkowsky 2017-11-16

Quantum Computing in Action Johan Vos 2022-03-22 Quantum computing is on the horizon and you can get started today! This practical, clear-spoken guide shows you don’t need a physics degree to write your first quantum software. In Quantum Computing in Action you will learn: An introduction to the core concepts of quantum computing Qubits and quantum gates Superposition, entanglement, and hybrid computing Quantum algorithms including Shor’s, Deutsch-jozsa, and Grover’s search Quantum Computing in Action shows you how to leverage your existing Java skills into writing your first quantum software, so you’re ready for the quantum revolution. This book is focused on practical implementations of quantum computing algorithms—there’s no deep math or confusing theory. Using Strange, a Java-based quantum computer simulator, you’ll go hands-on with quantum computing’s core components including qubits and quantum gates. About the technology Quantum computing promises unimaginably fast performance for tasks like encryption, scientific modeling, manufacturing logistics, financial modeling, and AI. Developers can explore quantum computing now using free simulators, and increasingly powerful true quantum systems are gradually becoming available for production use. This book gives you a head start on quantum computing by introducing core concepts, key algorithms, and the most beneficial use cases. About the book Quantum Computing in Action is a gentle introduction to the ideas and applications of quantum computing. After briefly reviewing the science that makes quantum tick, it guides you through practical implementations of quantum computing algorithms. You’ll write your first quantum code and explore qubits and quantum gates with the Java-based Strange quantum simulator. You’ll enjoy the interesting examples and insightful explanations as you create quantum algorithms using standard Java and your favorite IDE and build tools. What's inside An introduction to the core concepts of quantum computing Qubits and quantum gates Superposition, entanglement, and hybrid computing Quantum algorithms including Shor’s, Deutsch-jozsa, and Grover’s search About the reader For Java developers. No advanced math knowledge required. About the author Johan Vos is a cofounder of Gluon, a Java technology company. He is a Java Champion and holds an MSc in Mining Engineering and a PhD in Applied Physics. Table of Contents PART 1 QUANTUM COMPUTING INTRODUCTION 1 Evolution, revolution, or hype? 2 “Hello World,” quantum computing style 3 Qubits and quantum gates: The basic units in quantum computing PART 2 FUNDAMENTAL CONCEPTS AND HOW THEY RELATE TO CODE 4 Superposition 5 Entanglement 6 Quantum networking: The basics PART 3 QUANTUM ALGORITHMS AND CODE 7 Our HelloWorld, explained 8 Secure communication using quantum computing 9 Deutsch-Jozsa algorithm 10 Grover’s search algorithm 11 Shor’s algorithm

Classical and Quantum Computation Alexei Yu. Kitaev 2002 This book presents a concise introduction to an emerging and increasingly important topic, the theory of quantum computing. The development of quantum computing exploded in 1994 with the discovery of its use in factoring large numbers--an extremely difficult and time-consuming problem when using a conventional computer. In less than 300 pages, the authors set forth a solid foundation to the theory, including results that have not appeared elsewhere and improvements on existing works. The book starts with the basics of classical theory of computation, including NP-complete problems and the idea of complexity of an algorithm. Then the authors introduce general principles of quantum computing and pass to the study of main quantum computation algorithms: Grover's algorithm, Shor's factoring algorithm, and the Abelian hidden subgroup problem. In concluding sections, several related topics are discussed (parallel quantum computation, a quantum analog of NP-completeness, and quantum error-correcting codes). This is a suitable textbook for a graduate course in quantum computing. Prerequisites are very modest and include linear algebra, elements of group theory and probability, and the notion of an algorithm (on a formal or an intuitive level). The book is complete with problems, solutions, and an appendix summarizing the necessary results from number theory.

Quantum Computing National Academies of Sciences, Engineering, and Medicine 2019-04-27 Quantum mechanics, the subfield of physics that describes the behavior of very small (quantum) particles, provides the basis for a new paradigm of computing. First proposed in the 1980s as a way to improve computational modeling of quantum systems, the field of quantum computing has recently garnered significant attention due to progress in building small-scale devices. However, significant technical advances will be required before a large-scale, practical quantum computer can be achieved. Quantum Computing: Progress and Prospects provides an introduction to the field, including the unique characteristics and constraints of the technology, and assesses the feasibility and implications of creating a functional quantum computer capable of addressing real-world problems. This report considers hardware and software requirements, quantum algorithms, drivers of advances in quantum computing and quantum devices, benchmarks associated with relevant use cases, the time and resources required, and how to assess the probability of success.

New Kind of Science Stephen Wolfram 2002-12-01

Quantum Proofs Thomas Vidick 2016-03-30 Quantum Proofs provides an overview of many of the known results concerning quantum proofs, computational models based on this concept, and properties of the complexity classes they define. In particular, it discusses non-interactive proofs and the complexity class QMA, single-prover quantum interactive proof systems and the complexity class QIP, statistical zero-knowledge quantum interactive proof systems and the complexity class QSZK, and multiprover interactive proof systems and the complexity classes QMIP, QMIP*, and MIP*. Quantum Proofs is mainly intended for non-specialists having a basic background in complexity theory and quantum information. A typical reader may be a student or researcher in either area desiring to learn about the fundamentals of the (actively developing) theory of quantum interactive proofs.

Quantum Computing Since Democritus Scott Aaronson 2013 Takes students and researchers on a tour through some of the deepest ideas of maths, computer science and physics.

The Theory of Quantum Information John Watrous 2018-04-26 Formal development of the mathematical theory of quantum information with clear proofs and exercises. For graduate students and researchers.

Consistent Quantum Theory Robert B. Griffiths 2003-11-13 Quantum mechanics is one of the most

fundamental yet difficult subjects in physics. Nonrelativistic quantum theory is presented here in a clear and systematic fashion, integrating Born's probabilistic interpretation with Schrödinger dynamics. Basic quantum principles are illustrated with simple examples requiring no mathematics beyond linear algebra and elementary probability theory. The quantum measurement process is consistently analyzed using fundamental quantum principles without referring to measurement. These same principles are used to resolve several of the paradoxes that have long perplexed physicists, including the double slit and Schrödinger's cat. The consistent histories formalism used here was first introduced by the author, and extended by M. Gell-Mann, J. Hartle and R. Omnès. Essential for researchers yet accessible to advanced undergraduate students in physics, chemistry, mathematics, and computer science, this book is supplementary to standard textbooks. It will also be of interest to physicists and philosophers working on the foundations of quantum mechanics.

Quantum Computing since Democritus Scott Aaronson 2013-03-14 Written by noted quantum computing theorist Scott Aaronson, this book takes readers on a tour through some of the deepest ideas of maths, computer science and physics. Full of insights, arguments and philosophical perspectives, the book covers an amazing array of topics. Beginning in antiquity with Democritus, it progresses through logic and set theory, computability and complexity theory, quantum computing, cryptography, the information content of quantum states and the interpretation of quantum mechanics. There are also extended discussions about time travel, Newcomb's Paradox, the anthropic principle and the views of Roger Penrose. Aaronson's informal style makes this fascinating book accessible to readers with scientific backgrounds, as well as students and researchers working in physics, computer science, mathematics and philosophy.

Pairwise Independence and Derandomization Michael George Luby 2006 Pairwise Independence and Derandomization gives several applications of the following paradigm, which has proven extremely powerful in algorithm design and computational complexity. First, design a probabilistic algorithm for a given problem. Then, show that the correctness analysis of the algorithm remains valid even when the random strings used by the algorithm do not come from the uniform distribution, but rather from a small sample space, appropriately chosen. In some cases this can be proven directly (giving "unconditional derandomization"), and in others it uses computational assumptions, like the existence of 1-way functions (giving "conditional derandomization"). Pairwise Independence and Derandomization is self contained, and is a prime manifestation of the "derandomization" paradigm. It is intended for scholars and graduate students in the field of theoretical computer science interested in randomness, derandomization and their interplay with computational complexity.

The Quantum Age Brian Clegg 2014-06-05 The stone age, the iron age, the steam and electrical ages all saw the reach of humankind transformed by new technology. Now we are living in the quantum age, a revolution in everyday life led by our understanding of the very, very small. Quantum physics lies at the heart of every electronic device from smartphones to lasers; quantum superconductors allow levitating trains and MRI scanners, while superfast, ultra-secure quantum computers may soon be a reality. Yet quantum particles such as atoms, electrons and photons remain mysterious, acting totally unlike the objects we experience directly. With his trademark clarity and enthusiasm, acclaimed popular science author Brian Clegg reveals the amazing world of the quantum that lies all around us.

Quantum Theory Cannot Hurt You Marcus Chown 2008-09-04 The two towering achievements of modern physics are quantum theory and Einstein's general theory of relativity. Together, they explain virtually everything about the world we live in. But, almost a century after their advent, most people haven't the slightest clue what either is about. Did you know that there's so much empty space inside

matter that the entire human race could be squeezed into the volume of a sugar cube? Or that you grow old more quickly on the top floor of a building than on the ground floor? And did you realize that 1% of the static on a TV tuned between stations is the relic of the Big Bang? Marcus Chown, the bestselling author of What A Wonderful World and the Solar System app, explains all with characteristic wit, colour and clarity, from the Big Bang and Einstein's general theory of relativity to probability, gravity and quantum theory. 'Chown discusses special and general relativity, probablity waves, quantum entanglement, gravity and the Big Bang, with humour and beautiful clarity, always searching for the most vivid imagery.' Steven Poole, Guardian

The Quantum Spy David Ignatius 2017-11-14 Who will rule the world? A nail-biting technothriller from a bestselling master A quantum computer is the digital equivalent of a nuclear bomb; whoever possesses one will be able to attain global dominance. The question is, who will get there first? A top-secret quantum research lab is compromised by a suspected Chinese informant. CIA officer Harris Chang leads the mole hunt, pursuing his target from the towering cityscape of Singapore to the mountains of Mexico and beyond. The investigation is obsessive, destructive, and uncertain... In order to win, Chang must question everything he knows. Grounded in a real-world technological arms race, The Quantum Spy presents a sophisticated game of cat and mouse cloaked in an exhilarating and visionary thriller. Perfect for fans of Tom Clancy, Stephen Coonts and David Baldacci.

The Theoretical Minimum Leonard Susskind 2014-04-22 A master teacher presents the ultimate introduction to classical mechanics for people who are serious about learning physics "Beautifully clear explanations of famously 'difficult' things," -- Wall Street Journal If you ever regretted not taking physics in college -- or simply want to know how to think like a physicist -- this is the book for you. In this bestselling introduction to classical mechanics, physicist Leonard Susskind and hacker-scientist George Hrabovsky offer a first course in physics and associated math for the ardent amateur. Challenging, lucid, and concise, The Theoretical Minimum provides a tool kit for amateur scientists to learn physics at their own pace.

Reinventing Discovery Michael Nielsen 2020-04-07 How the internet and powerful online tools are democratizing and accelerating scientific discovery Reinventing Discovery argues that we are living at the dawn of the most dramatic change in science in more than three hundred years. This change is being driven by powerful cognitive tools, enabled by the internet, which are greatly accelerating scientific discovery. There are many books about how the internet is changing business, the workplace, or government. But this is the first book about something much more fundamental: how the internet is transforming our collective intelligence and our understanding of the world. From the collaborative mathematicians of the Polymath Project to the amateur astronomers of Galaxy Zoo, Reinventing Discovery tells the exciting story of the unprecedented new era in networked science. It will interest anyone who wants to learn about how the online world is revolutionizing scientific discovery—and why the revolution is just beginning.

Complexity and Control in Quantum Photonics Peter Shadbolt 2015-09-22 This work explores the scope and flexibility afforded by integrated quantum photonics, both in terms of practical problem-solving, and for the pursuit of fundamental science. The author demonstrates and fully characterizes a two-qubit quantum photonic chip, capable of arbitrary two-qubit state preparation. Making use of the unprecedented degree of reconfigurability afforded by this device, a novel variation on Wheeler’s delayed choice experiment is implemented, and a new technique to obtain nonlocal statistics without a shared reference frame is tested. Also presented is a new algorithm for quantum chemistry, simulating the helium hydride ion. Finally, multiphoton quantum interference in a large Hilbert space is

demonstrated, and its implications for computational complexity are examined.

Mastering Quantum Computing with IBM QX Dr Christine Corbett Moran 2019-01-31 Learn quantum computing by implementing quantum programs on IBM QX and be at the forefront of the next revolution in computation Key Features Learn quantum computing through programming projects Run, test, and debug your quantum programs with the fully integrated IBM QX Use Qiskit to create, compile, and execute quantum computing programs Book Description Quantum computing is set to disrupt the industry. IBM Research has made quantum computing available to the public for the first time, providing cloud access to IBM QX from any desktop or mobile device. Complete with cutting-edge practical examples, this book will help you understand the power of quantum computing in the real world. Mastering Quantum Computing with IBM QX begins with the principles of quantum computing and the areas in which they can be applied. You'll explore the IBM Ecosystem, which enables quantum development with Quantum Composer and Qiskit. As you progress through the chapters, you'll implement algorithms on the quantum processor and learn how quantum computations are actually performed. By the end of the book, you will completely understand how to create quantum programs of your own, the impact of quantum computing on your business, and how to future-proof your programming career. What you will learn Study the core concepts and principles of quantum computing Uncover the areas in which quantum principles can be applied Design programs with quantum logic Understand how a quantum computer performs computations Work with key quantum computational algorithms including Shor's algorithm and Grover's algorithm Develop the ability to analyze the potential of quantum computing in your industry Who this book is for If you're a developer or data scientist interested in learning quantum computing, this book is for you. You're expected to have basic understanding of Python language, however in-depth knowledge of quantum physics is not required.

Schrödinger's Killer App Jonathan P. Dowling 2013-05-07 The race is on to construct the first quantum code breaker, as the winner will hold the key to the entire Internet. From international, multibillion-dollar financial transactions to top-secret government communications, all would be vulnerable to the secret-code-breaking ability of the quantum computer. Written by a renowned quantum physicist closely involved in the U.S. government’s development of quantum information science, Schrödinger’s Killer App: Race to Build the World’s First Quantum Computer presents an inside look at the government’s quest to build a quantum computer capable of solving complex mathematical problems and hacking the public-key encryption codes used to secure the Internet. The "killer application" refers to Shor’s quantum factoring algorithm, which would unveil the encrypted communications of the entire Internet if a quantum computer could be built to run the algorithm. Schrödinger’s notion of quantum entanglement—and his infamous cat—is at the heart of it all. The book develops the concept of entanglement in the historical context of Einstein’s 30-year battle with the physics community over the true meaning of quantum theory. It discusses the remedy to the threat posed by the quantum code breaker: quantum cryptography, which is unbreakable even by the quantum computer. The author also covers applications to other important areas, such as quantum physics simulators, synchronized clocks, quantum search engines, quantum sensors, and imaging devices. In addition, he takes readers on a philosophical journey that considers the future ramifications of quantum technologies. Interspersed with amusing and personal anecdotes, this book presents quantum computing and the closely connected foundations of quantum mechanics in an engaging manner accessible to non-specialists. Requiring no formal training in physics or advanced mathematics, it explains difficult topics, including quantum entanglement, Schrödinger’s cat, Bell’s inequality, and quantum computational complexity, using simple analogies.

Dancing with Qubits Robert S. Sutor 2019-11-28 Explore the principles and practicalities of quantum

computing Key FeaturesDiscover how quantum computing works and delve into the math behind it with this quantum computing textbookLearn how it may become the most important new computer technology of the centuryExplore the inner workings of quantum computing technology to quickly process complex cloud data and solve problemsBook Description Quantum computing is making us change the way we think about computers. Quantum bits, a.k.a. qubits, can make it possible to solve problems that would otherwise be intractable with current computing technology. Dancing with Qubits is a quantum computing textbook that starts with an overview of why quantum computing is so different from classical computing and describes several industry use cases where it can have a major impact. From there it moves on to a fuller description of classical computing and the mathematical underpinnings necessary to understand such concepts as superposition, entanglement, and interference. Next up is circuits and algorithms, both basic and more sophisticated. It then nicely moves on to provide a survey of the physics and engineering ideas behind how quantum computing hardware is built. Finally, the book looks to the future and gives you guidance on understanding how further developments will affect you. Really understanding quantum computing requires a lot of math, and this book doesn't shy away from the necessary math concepts you'll need. Each topic is introduced and explained thoroughly, in clear English with helpful examples. What you will learnSee how quantum computing works, delve into the math behind it, what makes it different, and why it is so powerful with this quantum computing textbookDiscover the complex, mind-bending mechanics that underpin quantum systemsUnderstand the necessary concepts behind classical and quantum computingRefresh and extend your grasp of essential mathematics, computing, and quantum theoryExplore the main applications of quantum computing to the fields of scientific computing, AI, and elsewhereExamine a detailed overview of qubits, quantum circuits, and quantum algorithmWho this book is for Dancing with Qubits is a quantum computing textbook for those who want to deeply explore the inner workings of quantum computing. This entails some sophisticated mathematical exposition and is therefore best suited for those with a healthy interest in mathematics, physics, engineering, and computer science.

An Introduction to Quantum Computing Phillip Kaye 2007 The authors provide an introduction to quantum computing. Aimed at advanced undergraduate and beginning graduate students in these disciplines, this text is illustrated with diagrams and exercises.

Quantum Enigma Bruce Rosenblum 2011-08-01 In trying to understand the atom, physicists built quantum mechanics, the most successful theory in science and the basis of one-third of our economy. They found, to their embarrassment, that with their theory, physics encounters consciousness. Authors Bruce Rosenblum and Fred Kuttner explain all this in non-technical terms with help from some fanciful stories and anecdotes about the theory's developers. They present the quantum mystery honestly, emphasizing what is and what is not speculation. Quantum Enigma's description of the experimental quantum facts, and the quantum theory explaining them, is undisputed. Interpreting what it all means, however, is heatedly controversial. But every interpretation of quantum physics involves consciousness. Rosenblum and Kuttner therefore turn to exploring consciousness itself--and encounter quantum mechanics. Free will and anthropic principles become crucial issues, and the connection of consciousness with the cosmos suggested by some leading quantum cosmologists is mind-blowing. Readers are brought to a boundary where the particular expertise of physicists is no longer the only sure guide. They will find, instead, the facts and hints provided by quantum mechanics and the ability to speculate for themselves. In the few decades since the Bell's theorem experiments established the existence of entanglement (Einstein's "spooky action"), interest in the foundations, and the mysteries, of quantum mechanics has accelerated. In recent years, physicists, philosophers, computer engineers, and even biologists have expanded our realization of the significance of quantum phenomena. This second edition includes such advances. The authors have also drawn on many responses from readers and instructors to improve the

clarity of the book's explanations.

Quantum Computing Since Democritus Scott Aaronson 2013-03-14 Takes students and researchers on a tour through some of the deepest ideas of maths, computer science and physics.

Computing with Quantum Cats John Gribbin 2015-07 Pioneering study of the science behind quantum computing and what the new quantum reality will mean for mankind. The quantum computer is no longer the stuff of science fiction. Pioneering physicists are on the brink of unlocking a new quantum universe which provides a better representation of reality than our everyday experiences and common sense ever could. The birth of quantum computers -- which, like Schrodinger's famous 'dead and alive' cat, rely on entities like electrons, photons or atoms existing in two states at the same time -- is set to turn the computing world on its head. In his fascinating study of this cutting-edge technology, John Gribbin updates his previous views on the nature of quantum reality, arguing for a universe of many parallel worlds where 'everything is real'. Looking back to Alan Turing's work on the Enigma machine and the first electronic computer, Gribbin explains how quantum theory developed to make quantum computers work in practice as well as in principle. He takes us beyond the arena of theoretical physics to explore their practical applications -- from machines which learn through 'intuition' and trial and error to unhackable laptops and smartphones. And he investigates the potential for this extraordinary science to create a world where communication occurs faster than light and teleportation is possible."

Quantum Computing for Beginners Simon Edwards 2020-01-27 Discover Quantum Computing, a Technology That Will Soon Change the World! Do you want to discover the upcoming tech that will change the IT industry forever? In 2019, Google shocked the world by announcing that their quantum computer called Sycamore solved an impossible problem. Apparently, Sycamore solved it in less than 200 seconds. It would take over 10 000 years for "normal" computers to do that, even the most powerful ones. Impressive, right? But you might wonder, why is it such a big deal? The answer lies in the implications of such technology. Quantum computers could revolutionize scientific discoveries, boost the development of medicine, make a huge breakthrough in the field of artificial intelligence, and literally save the world from the climate catastrophe. Do you want to know how a computer can do all that? Turn to this ultimate guide on quantum computing! Inside, you'll discover an ocean of information about this technology, including some you won't find anywhere else! Here's what you'll learn: What is Quantum Computing and how quantum computers operate Why is this technology the future of the IT sector How close are we to building a quantum computer Description of various algorithms and how they work The possible implementations of quantum computing and how it can change the world And much more! You don't have to be an expert or have an IT degree to understand the mechanics of quantum computing. At least, not with this book. Even though the topic is extremely technical, this book is written in a way anyone can understand. You won't get lost on the first page and give up. You have a chance to learn everything about a technology that might prove the most important tech in the years to come! So don't hesitate and use this opportunity to become a part of a computing revolution! Scroll up, click on "Buy Now with 1-Click", and Get Your Copy Now!

Introduction to Information Retrieval and Quantum Mechanics Massimo Melucci 2015-12-08 This book introduces the quantum mechanical framework to information retrieval scientists seeking a new perspective on foundational problems. As such, it concentrates on the main notions of the quantum mechanical framework and describes an innovative range of concepts and tools for modeling information representation and retrieval processes. The book is divided into four chapters. Chapter 1 illustrates the main modeling concepts for information retrieval (including Boolean logic, vector spaces, probabilistic models, and machine-learning based approaches), which will be examined further in subsequent

chapters. Next, chapter 2 briefly explains the main concepts of the quantum mechanical framework, focusing on approaches linked to information retrieval such as interference, superposition and entanglement. Chapter 3 then reviews the research conducted at the intersection between information retrieval and the quantum mechanical framework. The chapter is subdivided into a number of topics, and each description ends with a section suggesting the most important reference resources. Lastly, chapter 4 offers suggestions for future research, briefly outlining the most essential and promising research directions to fully leverage the quantum mechanical framework for effective and efficient information retrieval systems. This book is especially intended for researchers working in information retrieval, database systems and machine learning who want to acquire a clear picture of the potential offered by the quantum mechanical framework in their own research area. Above all, the book offers clear guidance on whether, why and when to effectively use the mathematical formalism and the concepts of the quantum mechanical framework to address various foundational issues in information retrieval.

Quantum Computing for Everyone Chris Bernhardt 2019-03-19 An accessible introduction to an exciting new area in computation, explaining such topics as qubits, entanglement, and quantum teleportation for the general reader. Quantum computing is a beautiful fusion of quantum physics and computer science, incorporating some of the most stunning ideas from twentieth-century physics into an entirely new way of thinking about computation. In this book, Chris Bernhardt offers an introduction to quantum computing that is accessible to anyone who is comfortable with high school mathematics. He explains qubits, entanglement, quantum teleportation, quantum algorithms, and other quantum-related topics as clearly as possible for the general reader. Bernhardt, a mathematician himself, simplifies the mathematics as much as he can and provides elementary examples that illustrate both how the math works and what it means. Bernhardt introduces the basic unit of quantum computing, the qubit, and explains how the qubit can be measured; discusses entanglement—which, he says, is easier to describe mathematically than verbally—and what it means when two qubits are entangled (citing Einstein's characterization of what happens when the measurement of one entangled qubit affects the second as "spooky action at a distance"); and introduces quantum cryptography. He recaps standard topics in classical computing—bits, gates, and logic—and describes Edward Fredkin's ingenious billiard ball computer. He defines quantum gates, considers the speed of quantum algorithms, and describes the building of quantum computers. By the end of the book, readers understand that quantum computing and classical computing are not two distinct disciplines, and that quantum computing is the fundamental form of computing. The basic unit of computation is the qubit, not the bit.

Quantum Computing Eleanor G. Rieffel 2014-08-29 A thorough exposition of quantum computing and the underlying concepts of quantum physics, with explanations of the relevant mathematics and numerous examples. The combination of two of the twentieth century's most influential and revolutionary scientific theories, information theory and quantum mechanics, gave rise to a radically new view of computing and information. Quantum information processing explores the implications of using quantum mechanics instead of classical mechanics to model information and its processing. Quantum computing is not about changing the physical substrate on which computation is done from classical to quantum but about changing the notion of computation itself, at the most basic level. The fundamental unit of computation is no longer the bit but the quantum bit or qubit. This comprehensive introduction to the field offers a thorough exposition of quantum computing and the underlying concepts of quantum physics, explaining all the relevant mathematics and offering numerous examples. With its careful development of concepts and thorough explanations, the book makes quantum computing accessible to students and professionals in mathematics, computer science, and engineering. A reader with no prior knowledge of quantum physics (but with sufficient knowledge of linear algebra) will be able to gain a fluent understanding by working through the book.

Quantum Computer Science N. David Mermin 2007-08-30 In the 1990's it was realized that quantum physics has some spectacular applications in computer science. This book is a concise introduction to quantum computation, developing the basic elements of this new branch of computational theory without assuming any background in physics. It begins with an introduction to the quantum theory from a computer-science perspective. It illustrates the quantum-computational approach with several elementary examples of quantum speed-up, before moving to the major applications: Shor's factoring algorithm, Grover's search algorithm, and quantum error correction. The book is intended primarily for computer scientists who know nothing about quantum theory, but will also be of interest to physicists who want to learn the theory of quantum computation, and philosophers of science interested in quantum foundational issues. It evolved during six years of teaching the subject to undergraduates and graduate students in computer science, mathematics, engineering, and physics, at Cornell University.

Picturing Quantum Processes Bob Coecke 2017-03-16 The unique features of the quantum world are explained in this book through the language of diagrams, setting out an innovative visual method for presenting complex theories. Requiring only basic mathematical literacy, this book employs a unique formalism that builds an intuitive understanding of quantum features while eliminating the need for complex calculations. This entirely diagrammatic presentation of quantum theory represents the culmination of ten years of research, uniting classical techniques in linear algebra and Hilbert spaces with cutting-edge developments in quantum computation and foundations. Written in an entertaining and user-friendly style and including more than one hundred exercises, this book is an ideal first course in quantum theory, foundations, and computation for students from undergraduate to PhD level, as well as an opportunity for researchers from a broad range of fields, from physics to biology, linguistics, and cognitive science, to discover a new set of tools for studying processes and interaction.

Quantum Algorithms via Linear Algebra Richard J. Lipton 2014-12-05 Quantum computing explained in terms of elementary linear algebra, emphasizing computation and algorithms and requiring no background in physics. This introduction to quantum algorithms is concise but comprehensive, covering many key algorithms. It is mathematically rigorous but requires minimal background and assumes no knowledge of quantum theory or quantum mechanics. The book explains quantum computation in terms of elementary linear algebra; it assumes the reader will have some familiarity with vectors, matrices, and their basic properties, but offers a review of all the relevant material from linear algebra. By emphasizing computation and algorithms rather than physics, this primer makes quantum algorithms accessible to students and researchers in computer science without the complications of quantum mechanical notation, physical concepts, and philosophical issues. After explaining the development of quantum operations and computations based on linear algebra, the book presents the major quantum algorithms, from seminal algorithms by Deutsch, Jozsa, and Simon through Shor's and Grover's algorithms to recent quantum walks. It covers quantum gates, computational complexity, and some graph theory. Mathematical proofs are generally short and straightforward; quantum circuits and gates are used to illuminate linear algebra; and the discussion of complexity is anchored in computational problems rather than machine models. Quantum Algorithms via Linear Algebra is suitable for classroom use or as a reference for computer scientists and mathematicians.

Quantum Computation and Quantum Information Michael A. Nielsen 2000-10-23 First-ever comprehensive introduction to the major new subject of quantum computing and quantum information.

Quantum Computing Since Democritus Scott Aaronson 2014-05-14 Takes students and researchers on a tour through some of the deepest ideas of maths, computer science and physics.

The Nature of Computation Cristopher Moore 2011-08-11 Computational complexity is one of the most beautiful fields of modern mathematics, and it is increasingly relevant to other sciences ranging from physics to biology. But this beauty is often buried underneath layers of unnecessary formalism, and exciting recent results like interactive proofs, phase transitions, and quantum computing are usually considered too advanced for the typical student. This book bridges these gaps by explaining the deep ideas of theoretical computer science in a clear and enjoyable fashion, making them accessible to non-computer scientists and to computer scientists who finally want to appreciate their field from a new point of view. The authors start with a lucid and playful explanation of the P vs. NP problem, explaining why it is so fundamental, and so hard to resolve. They then lead the reader through the complexity of mazes and games; optimization in theory and practice; randomized algorithms, interactive proofs, and pseudorandomness; Markov chains and phase transitions; and the outer reaches of quantum computing. At every turn, they use a minimum of formalism, providing explanations that are both deep and accessible. The book is intended for graduate and undergraduate students, scientists from other areas who have long wanted to understand this subject, and experts who want to fall in love with this field all over again.

One Two Three . . . Infinity George Gamow 1971-05

Programming the Universe Seth Lloyd 2006-03-14 Is the universe actually a giant quantum computer? According to Seth Lloyd, the answer is yes. All interactions between particles in the universe, Lloyd explains, convey not only energy but also information–in other words, particles not only collide, they compute. What is the entire universe computing, ultimately? “Its own dynamical evolution,” he says. “As the computation proceeds, reality unfolds.” Programming the Universe, a wonderfully accessible book, presents an original and compelling vision of reality, revealing our world in an entirely new light.