Quantum Computing For Computer Scientists

In this text we present a technical overview of the emerging field of quantum computation along with new research results by the authors. What distinguishes our presentation from that of others is our focus on the relationship between quantum computation and computer science. Specifically, our emphasis is on the computational model of quantum computing rather than on the engineering issues associated with its physical implementation. We adopt this approach for the same reason that a book on computer programming doesn't cover the theory and physical realization of semiconductors. Another distinguishing feature of this text is our detailed discussion of the circuit complexity of quantum algorithms. To the extent possible we have presented the material in a form that is accessible to the computer scientist, but in many cases we retain the conventional physics notation so that the reader will also be able to consult the relevant quantum computing literature. Although we expect the reader to have a solid understanding of linear algebra, we do not assume a background in physics. This text is based on lectures given as short courses and invited presentations around the world, and it has been used as the primary text for a graduate course at George Mason University. In all these cases our challenge has been the same: how to present to a general audience a concise introduction to the algorithmic structure and applications of quantum computing on an extremely short period of time. The feedback from these courses and presentations has greatly aided in making our exposition of challenging concepts more accessible to a general audience. Table of Contents: Introduction / The Algorithmic Structure of Quantum Computing / Advantages and Limitations of Quantum Computing / Amplitude Amplification / Case Study: Computational Geometry / The Quantum Fourier Transform / Case Study: The Hidden Subgroup / Circuit Complexity Analysis of Quantum Algorithms / Conclusions / Bibliography

By the year 2020, the basic memory components of a computer will be the size of individual atoms. At such scales, the current theory of computation will become invalid. "Quantum computing" is reinventing the foundations of computer science and information theory in a way that is consistent with quantum physics - the most accurate model of reality currently known. Remarkably, this theory predicts that quantum computers can perform certain tasks breathtakingly faster than classical computers - and, better yet, can accomplish mind-boggling feats such as teleporting information, breaking supposedly "unbreakable" codes, generating true random numbers, and communicating with messages that betray the presence of eavesdropping. This widely anticipated second edition of Explorations in Quantum Computing explains these burgeoning developments in simple terms, and describes the key technological hurdles that must be overcome to make quantum computers a reality. This easy-to-read, time-tested, and comprehensive textbook provides a fresh perspective on the capabilities of quantum computers, and supplies readers with the tools necessary to make their own foray into this exciting field. Topics and features: concludes each chapter with exercises and a summary of the material covered; provides an introduction to the basic mathematical formalism of quantum computing, and the quantum effects that can be harnessed for non-classical computation; discusses the concepts of quantum gates, entangling power, quantum circuits, quantum Fourier, wavelet, and cosine transforms, and quantum universality, computability, and complexity; examines the potential applications of quantum computers in areas such as search, code-breaking, solving NP-Complete problems, quantum simulation, quantum chemistry, and mathematics; investigates the uses of quantum information, including quantum teleportation, superdense coding, quantum data compression, quantum cloning, quantum negation, and quantum cryptography; reviews the advancements made towards practical quantum computers, covering developments in quantum error correction and avoidance, and alternative models of quantum computation. This text/reference is ideal for anyone wishing to learn more about this incredible, perhaps "ultimate," computer revolution. Dr. Colin P. Williams is Program Manager for Advanced Computing Paradigms at the NASA Jet Propulsion Laboratory, California Institute of Technology, and CEO of Xtreme Energetics, Inc. an advanced solar energy company. Dr. Williams has taught quantum computing and quantum information theory as an acting Associate Professor of Computer Science at Stanford University. He has spent over a decade inspiring and leading high technology teams and building business relationships with and Silicon Valley companies. Today his interests include terrestrial and Space-based power generation, quantum computing, cognitive computing, computational material design, visualization, artificial intelligence, evolutionary computing, and remote olfaction. He was formerly a Research Scientist at Xerox PARC and a Research Assistant to Prof. Stephen W. Hawking, Cambridge University.

This book contains selected papers presented at the First NASA International Conference on Quantum Computing and Quantum Communications, QCQC'98, held in Palm Springs, California, USA in February 1998. As the record of the first large-scale meeting entirely devoted to quantum computing and communications, this book is a unique survey of the state-of-the-art in the area. The 43 carefully reviewed papers are organized in topical sections on entanglement and quantum algorithms, quantum cryptography, quantum copying and quantum information theory, quantum error correction and fault-tolerant quantum computing, and embodiments of quantum computers.

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.

Programming Quantum Computers

Introduction to Quantum Computers

Programming the Universe

Automatic Quantum Computer Programming

Classical and Quantum Computing

This volume presents papers on the topics covered at the National Academy of Engineering's 2018 US Frontiers of Engineering Symposium. Every year the symposium brings together 100 outstanding young leaders in engineering to share their cutting-edge research and innovations in selected areas. The 2018 symposium was held September 5-7 and hosted by MIT Lincoln Laboratory in Lexington, Massachusetts. The intent of this book is to convey the excitement of this unique meeting and to highlight innovative developments in engineering research and technical work.

"Quantum computation, one of the latest joint ventures between physics and the theory of computation, is a scientific field whose main goals include the development of hardware and algorithms based on the quantum mechanical properties of those physical systems used to implement such algorithms." "Solving difficult tasks (for example, the Satisfiability Problem and other NP-complete problems) requires the development of sophisticated algorithms, many of which employ stochastic processes as their mathematical basis. Discrete random walks are a popular choice among those stochastic processes." "Inspired on the success of discrete random walks in algorithm development, quantum walks, an emerging field of quantum computation, is a generalization of random walks into the quantum mechanical world." "The purpose of this lecture is to provide a concise yet comprehensive introduction to quantum walks."--BOOK JACKET.

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.

This is a self-contained, systematic and comprehensive introduction to all the subjects and techniques important in scientific computing. The style and presentation are readily accessible to undergraduates and graduates. A large number of examples, accompanied by complete C++ and Java code wherever possible, cover every topic.

Quantum Computer Science

An Introduction to Quantum Computing

A Quantum Computer Scientist Takes on the Cosmos

An Overview

A Short Course from Theory to Experiment

In 1994 Peter Shor [65] published a factoring algorithm for a quantum computer that finds the prime factors of a composite integer N more efficiently than is possible with the known algorithms for a classical com puter. Since the difficulty of the factoring problem is crucial for the se curity of a public key encryption system, interest (and funding) in quan tum computing and quantum computation suddenly blossomed. Quan tum computing had arrived. The study of the role of quantum mechanics in the theory of computa tion seems to have begun in the early 1980s with the publications of Paul Benioff [6]' [7] who considered a quantum mechanical model of computers and the computation process. A related question was discussed shortly thereafter by Richard Feynman [35] who began from a different perspec tive by asking what kind of computer should be used to simulate physics. His analysis led him to the belief that with a suitable class of "quantum machines" one could imitate any quantum system.

In quantum computing, we witness an exciting and very promising merge of two of the deepest and most successful scientific and technological developments of this century: quantum physics and computer science. The book takes a very broad view of quantum computing and information processing in general. It deals with such areas as quantum algorithms, automata, complexity theory, information and communication, cryptography and theoretical results. These include such topics as quantum error correcting codes and methods of quantum fault tolerance computing, which have made the vision of a real quantum computer come closer. No previous knowledge of quantum mechanics is required. The book is written as a self-study introduction to quantum computing and can be used for a one-semester course on quantum computing, especially for computer scientists. To meet this aim the book contains numerous examples, figures and exercises.

While there are many available textbooks on quantum information theory, most are either too technical for beginners or not complete enough. Filling this gap, Elements of Quantum Computation and Quantum Communication gives a clear, self-contained introduction to quantum computation and communication. Written primarily for undergraduate students in p

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. --from publisher description.

Research for Noisy Intermediate-Scale Quantum Computers

Solving Real-World Problems Using Quantum Computing and Algorithms

Quantum Computing for Everyone

Quantum Computer Systems

Quantum Computing

The ultimate non-technical guide to the fast-developing world of quantum computing Computer technology has improved exponentially over the last 50 years. But the headroom for bigger and better electronic solutions is running out. Our best hope is to engage the power of quantum physics. 'Quantum algorithms' had already been written long before hardware was built. These would enable, for example, a quantum computer to exponentially speed up an information search, or to crack the mathematical trick behind internet security. However, making a quantum computer is incredibly difficult. Despite hundreds of laboratories around the world working on them, we are only just seeing them come close to 'supremacy' where they can outperform a traditional computer. In this approachable introduction, Brian Clegg explains algorithms and their quantum counterparts, explores the physical building blocks and quantum weirdness necessary to make a quantum computer, and uncovers the capabilities of the current generation of machines.

This book addresses a broad community of physicists, engineers, computer scientists and industry professionals, as well as the general public, who are aware of the unprecedented media hype surrounding the supposedly imminent new era of quantum computing. The central argument of this book is that the feasibility of quantum computing in the physical world is extremely doubtful. The hypothetical quantum computer is not simply a quantum variant of the conventional digital computer, but rather a quantum extension of a classical analog computer operating with continuous parameters. In order to have a useful machine, the number of continuous parameters to control would have to be of such an astronomically large magnitude as to render the endeavor virtually infeasible. This viewpoint is based on the author's expert understanding of the gargantuan challenges that would have to be overcome to ever make quantum computing a reality. Knowledge of secondary-school-level physics and math will be sufficient for understanding most of the text.

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.

This book targets computer scientists and engineers who are familiar with concepts in classical computer systems but are curious to learn the general architecture of quantum computing systems. It gives a concise presentation of this new paradigm of computing from a computer systems' point of view without assuming any background in quantum mechanics. As such, it is divided into two parts. The first part of the book provides a gentle overview on the fundamental principles of the quantum theory and their implications for computing. The second part is devoted to state-of-the-art research in designing practical quantum programs, building a scalable software systems stack, and controlling quantum hardware components. Most chapters end with a summary and an outlook for future directions. This book celebrates the remarkable progress that scientists across disciplines have made in the past decades and reveals what roles computer scientists and engineers can play to enable practical-scale quantum computing.

Will We Ever Have a Quantum Computer?

Quantum Information

Frontiers of Engineering

The Transformative Technology of the Qubit Revolution

Quantum Computing and Quantum Communications

Quantum computation, one of the latest joint ventures between physics and the theory of computation, is a scientific field whose main goals include the development of hardware and algorithms based on the quantum mechanical properties of those physical systems used to implement such algorithms. Solving difficult tasks (for example, the Satisfiability Problem and other NP-complete problems) requires the development of sophisticated algorithms, many ofwhich employ stochastic processes as their mathematical basis. Discrete random walks are a popular choice among those stochastic processes. Inspired on the success of discrete random walks in algorithm development, quantum walks, an emerging field of quantum computation, is a generalization of random walks into the quantum mechanical world. The purpose of this lecture is to provide a concise yet comprehensive introduction to quantum walks. Table of Contents: Introduction / Quantum Mechanics / Theory of Computation / Classical Random Walks / Quantum Walks / Computer Science and Quantum Walks / Conclusions

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.

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.

The result of a lecture series, this textbook is oriented towards students and newcomers to the field and discusses theoretical foundations as well as experimental realizations in detail. The authors are experienced teachers and have tailored this book to the needs of students. They present the basics of quantum communication and quantum information processing, leading readers to modern technical implementations. In addition, they discuss errors and decoherence as well as methods of avoiding and correcting them.

History, Theories and Engineering Applications

Elements of Quantum Computing

Explorations in Quantum Computing

Quantum Computing for the Quantum Curious

Quantum Computation and Quantum Information

Automatic Quantum Computer Programming provides an introduction to quantum computing for non-physicists, as well as an introduction to genetic programming for non-computer-scientists. The book explores several ways in which genetic programming can support automatic quantum computer programming and presents detailed descriptions of specific techniques, along with several examples of their human-competitive performance on specific problems. Source code for the author's QGAME quantum computer simulator is included as an appendix, and pointers to additional online resources furnish the reader with an array of tools for automatic quantum computer programming.

*A self-contained treatment of the fundamentals of quantum computing This clear, practical book takes quantum computing out of the realm of theoretical physics and teaches the fundamentals of the field to students and professionals who have not had training in quantum computing or quantum information theory, including computer scientists, programmers, electrical engineers, mathematicians, physics students, and chemists. The author cuts through the conventions of typical jargon-laden physics books and instead presents the material through his unique "how-to" approach and friendly, conversational style. Readers will learn how to carry out calculations with explicit details and will gain a fundamental grasp of: * Quantum mechanics * Quantum computation * Teleportation * Quantum cryptography * Entanglement * Quantum algorithms * Error correction A number of worked examples are included so readers can see how quantum computing is done with their own eyes, while answers to similar end-of-chapter problems are provided for readers to check their own work as they learn to master the information. Ideal for professionals and graduate-level students alike, Quantum Computing Explained delivers the fundamentals of quantum computing readers need to be able to understand current research papers and go on to study more advanced quantum texts.*

This book is about quantum computing and quantum algorithms. The book starts with a chapter introducing the basic rules of quantum mechanics and how they can be used to build quantum circuits and perform computations. Further, Grover's algorithm is presented for unstructured search discussing its consequences and applications. Next, important techniques are discussed such as Quantum Fourier Transform and quantum phase estimation. Finally, Shor's algorithm for integer factorization is explained. At last, quantum walks are explained in detail covering both the discrete and continuous time models,and applications of this techniques are described for the design and analyses of quantum algorithms.

Quantum Computing is an ever-increasing field of interest both from a conceptual and applied standpoint. Quantum Computing, belonging to the so called "Quantum Information Science", is founded on the principles of Quantum Mechanics and Information Science. Quantum Mechanics has radically changed our vision and understanding of the physical reality and has had also an enormous technological and societal impact. On the other hand, the developing of Information Theory, including computer science and communications theory, made

possible the information "revolution" which had a deep impact on our everyday life. Quantum Computing then relates to the possibility to represent, process and manipulate information by using the principles of quantum mechanics. Apart the theoretical importance of quantum computing to further understand the quantum mechanical behavior of physical systems and the physical foundation of information itself at the most elementary level, probably the most interesting feature of Quantum Computing is related to the possibility to design and realize an actual quantum computer which processes information in the form of quantum-bits or qubits. The great interest of scientific community in the realization of such devices mainly concerns the common believe they could be enormously faster than their classical counterparts so allowing their employment in all the applied fields where computational power is a key feature. Furthermore, the study of Quantum Computing, both at the physical and computational level, would be very important for a deeper understanding of the quantum behavior of a very wide range of physical systems including condensed matter, living systems, elementary particles, astrophysical structures and so on. Despite the general theoretical basis of quantum computing are sufficiently understood, the actual realization of a general - purpose and really usable quantum computer has posed great difficulties so far, mainly related to the issue of "quantum decoherence", the computational speed and scalability many of which still remain substantially unsolved. This volume doesn't mean to represent a complete or a beginner guide to Quantum Computing but has the aim to present some of its most interesting and fascinating developments in different frontier areas related to both theoretical and applied aspects, such, for example, the possibility to realize a quantum superfast "hypercomputing" system using water molecules as physical substrate to process, storage and retrieve information; the connection between quantum computers and quantum gravity; the development of an "instantaneous quantum computer algorithm"; the realization of a universal quantum computer, of a brain-like quantum supercomputer and many others frontiers topics. The target audience of this book is then composed by scientists and researchers interested in the most advanced theoretical and applied developments of quantum computation and quantum information.
From Quantum Computing to Intelligence
Quantum Walks for Computer Scientists
Quantum Computing for Programmers
Reports on Leading-Edge Engineering from the 2018 Symposium
Elements of Quantum Computation and Quantum Communication

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.
This book gives an overview for practitioners and students of quantum physics and information science. It provides ready access to essential information on quantum information processing and communication, such as definitions, protocols and algorithms. Quantum information science is rarely found in clear and concise form. This book brings together this information from its various sources. It allows researchers and students in a range of areas including physics, photonics, solid-state electronics, nuclear magnetic resonance and information technology, in their applied and theoretical branches, to have this vital material directly at hand.
A mind-blowing glimpse into the near future, where quantum computing will have world-transforming effects. 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 Schrödinger'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. This is an exciting insider's look at the new frontier of computer science and its revolutionary implications.
"This introduction to quantum computing from a classical programmer's perspective is meant for students and practitioners alike. More than 25 fundamental algorithms are explained with full mathematical derivations and classical code for simulation, using an open-source code base developed from the ground up in Python and C++. After presenting the basics of quantum computing, the author focuses on algorithms and the infrastructure to simulate them efficiently, beginning with quantum teleportation, superdense coding, and Deutsch-Jozsa. Coverage of advanced algorithms includes the quantum supremacy experiment, quantum Fourier transform, phase estimation, Shor's algorithm, Grover's algorithm with derivatives, quantum random walks, and the Solovay-Kitaev algorithm for gate approximation. Quantum simulation is explored with the variational quantum eigensolver, quantum approximate optimization, and the Max-Cut and Subset-Sum algorithms. The book also discusses issues around programmer productivity, quantum noise, error correction, and challenges for quantum programming languages, compilers, and tools, with a final section on compiler techniques for transpilation"--
Quantum Computing Solutions
Progress and Prospects
with C++ and Java Simulations
A Genetic Programming Approach

Quantum Computing for Computer ScientistsCambridge University Press
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.
A quantum computer is a computer based on a computational model which uses quantum mechanics, which is a subfield of physics to study phenomena at the micro level. There has been a growing interest on quantum computing in the 1990's and some quantum computers at the experimental level were recently implemented. Quantum computers enable super-speed computation and can solve some important problems whose solutions were regarded impossible or intractable with traditional computers. This book provides a quick introduction to quantum computing for readers who have no backgrounds of both theory of computation and quantum mechanics. “Elements of Quantum Computing” presents the history, theories and engineering applications of quantum computing. The book is suitable to computer scientists, physicists and software engineers.
First-ever comprehensive introduction to the major new subject of quantum computing and quantum information.
Quantum Computing Explained
Computing with Quantum Cats
Essential Algorithms and Code Samples
Quantum Computing Since Democritus
Frontiers in Quantum Computing

You've heard that quantum computing is going to change the world. Now you can check it out for yourself. Learn how quantum computing works, and write programs that run on the IBM Q quantum computer, one of the world's first functioning quantum computers. Learn a simple way to apply quantum mechanics to computer programming. Create algorithms to solve intractable problems for classical computers, and discover how to explore the entire problem space at once to determine the optimal solution. Get your hands on the future of computing today. Quantum computing overhauls computer science. Problems such as designing life-saving drugs and super-large logistics problems that have been difficult or impossible for classical computers to handle can now be solved in moments. Quantum computing makes it possible to explore all possible solutions simultaneously and determine those that work, instead of iterating through each possibility sequentially. Work with quantum computers directly, instead of talking about them theoretically. Discover a new visual way of looking at quantum bits that makes quantum computing intuitive for computer programmers. Master the special properties that make them different, and more powerful, than classical bits. Control quantum bits with gates and create circuits to model complex problems. Write programs that run on real quantum machines to solve problems that classical computers struggle with. Dive into quantum optimization and cryptography. Get a head start on the technology that will drive computer science into the future. What You Need: Access to the IBM quantum computer, via any internet connection
This open access book makes quantum computing more accessible than ever before. A fast-growing field at the intersection of physics and computer science, quantum computing promises to have revolutionary capabilities far surpassing “classical” computation. Getting a grip on the science behind the hype can be tough: at its heart lies quantum mechanics, whose enigmatic concepts can be imposing for the novice. This classroom-tested textbook uses simple language, minimal math, and plenty of examples to explain the three key principles behind quantum computers: superposition, quantum measurement, and entanglement. It then goes on to explain how this quantum world opens up a whole new paradigm of computing. The book bridges the gap between popular science articles and advanced textbooks by making key ideas accessible with just high school physics as a prerequisite. Each unit is broken down into sections labelled by difficulty level, allowing the course to be tailored to the student’s experience of math and abstract reasoning. Problem sets and simulation-based labs of various levels reinforce the concepts described in the text and give the reader hands-on experience running quantum programs. This book can thus be used at the high school level after the AP or IB exams, in an extracurricular club, or as an independent project resource to give students a taste of what quantum computing is really about. At the college level, it can be used as a supplementary text to enhance a variety of courses in science and computing, or as a self-study guide for students who want to get ahead. Additionally, readers in business, finance, or industry will find it a quick and useful primer on the science behind computing’s future.
Quantum computing promises to solve problems which are intractable on digital computers. Highly parallel quantum algorithms can decrease the computational time for some problems by many orders of magnitude. This important book explains how quantum computers can do these amazing things. Several algorithms are illustrated: the discrete Fourier transform, Shor's algorithm for prime factorization; algorithms for quantum logic gates; physical implementations of quantum logic gates in ion traps and in spin chains; the simplest schemes for quantum error correction; correction of errors caused by imperfect resonant pulses; correction of errors caused by the nonresonant actions of a pulse; and numerical simulations of dynamical behavior of the quantum Control-Not gate. An overview of some basic elements of computer science is presented, including the Turing machine, Boolean algebra, and logic gates. The required quantum ideas are explained.
Know how to use quantum computing solutions involving artificial intelligence (AI) algorithms and applications across different disciplines. Quantum solutions involve building quantum algorithms that improve computational tasks within quantum computing, AI, data science, and machine learning. As opposed to quantum computer innovation, quantum solutions offer automation, cost reduction, and other efficiencies to the problems they tackle. Starting with the basics, this book covers subsystems and properties as well as the information processing network before covering quantum simulators. Solutions such as the Traveling Salesman Problem, quantum cryptography, scheduling, and cybersecurity are discussed in step-by-step detail. The book presents code samples based on real-life problems in a variety of industries, such as risk assessment and fraud detection in banking. In pharma, you will look at drug discovery and protein-folding solutions. Supply chain optimization and purchasing solutions are presented in the manufacturing domain. In the area of utilities, energy distribution and optimization problems and solutions are explained. Advertising scheduling and revenue optimization solutions are included from media and technology verticals. What You Will Learn Understand the mathematics behind quantum computing Know the solution benefits, such as automation, cost reduction, and efficiencies Be familiar with the quantum subsystems and properties, including states, protocols, operations, and transformations Be aware of the quantum classification algorithms: classifiers, and support and sparse support vector machines Use AI algorithms, including probability, walks, search, deep learning, and parallelism Who This Book Is For Developers in Python and other languages interested in quantum solutions. The secondary audience includes IT professionals and academia in mathematics and physics. A tertiary audience is those in industry verticals such as manufacturing, banking, and pharma.
First NASA International Conference, QCQC '98, Palm Springs, California, USA, February 17-20, 1998, Selected Papers
A Primer on Quantum Computing
Quantum Computing for Computer Scientists
From Colossus to Qubits
An Introduction

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.
This book traces the roots of intelligence down to quantum physics, and in particular, to quantum natural computing. The concept of intelligence is formalized in such a way that it can be referred to both human and robots, and therefore, the book is focused on a phenomenology of intelligent behavior, in general, regardless of its biological or physical origin. The simplest patterns of intelligent behavior, that are generalization and abstraction, can be found in classical recurrent nets that simulate static, periodic and chaotic attractors. However, only introduction of quantum recurrent nets (QRN), quantum resonance (QR) phenomenon, and quantum-inspired (iQ) systems opens up a closer look to phenomenological similarity between quantum algorithms and paradigms of intelligent behavior.
Takes students and researchers on a tour through some of the deepest ideas of maths, computer science and physics.
An Introduction to Quantum Computing Algorithms
A Gentle Introduction