

Read PDF Quantum Computing
For Computer Scientists

Quantum Computing For Computer Scientists

***This book addresses a broad
community of physicists,***

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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

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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

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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

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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

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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. Among the most exciting

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developments in science today is the design and construction of the quantum computer. Its realization will be the result of multidisciplinary efforts, but ultimately, it is mathematics that lies at the heart of theoretical

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***quantum computer science.
Mathematics of Quantum
Computation brings together
leading computer scientists,
mathematicians, and physicists
to provide the first
interdisciplinary but***

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***mathematically focused
exploration of the field's
foundations and state of the art.
Each section of the book
addresses an area of major
research, and does so with
introductory material that brings***

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newcomers quickly up to speed. Chapters that are more advanced include recent developments not yet published in the open literature. Information technology will inevitably enter into the realm of quantum

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mechanics, and, more than all the atomic, molecular, optical, and nanotechnology advances, it is the device-independent mathematics that is the foundation of quantum computer and information science.

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Mathematics of Quantum Computation offers the first up-to-date coverage that has the technical depth and breadth needed by those interested in the challenges being confronted at the frontiers of research.

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Adiabatic quantum computation (AQC) is an alternative to the better-known gate model of quantum computation. The two models are polynomially equivalent, but otherwise quite dissimilar: one property that

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distinguishes AQC from the gate model is its analog nature.

Quantum annealing (QA) describes a type of heuristic search algorithm that can be implemented to run in the native instruction set" of an AQC

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platform. D-Wave Systems Inc. manufactures {quantum annealing processor chips} that exploit quantum properties to realize QA computations in hardware. The chips form the centerpiece of a novel computing

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platform designed to solve NP-hard optimization problems. Starting with a 16-qubit prototype announced in 2007, the company has launched and sold increasingly larger models: the 128-qubit D-Wave One

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system was announced in 2010 and the 512-qubit D-Wave Two system arrived on the scene in 2013. A 1,000-qubit model is expected to be available in 2014. This monograph presents an introductory overview of this

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unusual and rapidly developing approach to computation. We start with a survey of basic principles of quantum computation and what is known about the AQC model and the QA algorithm paradigm. Next we

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review the D-Wave technology stack and discuss some challenges to building and using quantum computing systems at a commercial scale. The last chapter reviews some experimental efforts to

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understand the properties and capabilities of these unusual platforms. The discussion throughout is aimed at an audience of computer scientists with little background in quantum computation or in

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physics.

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

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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

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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:

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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

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***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***

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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

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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

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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

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Quantum Computing for the Quantum Curious

*Foundations of Quantum
Programming discusses how new
programming methodologies and
technologies developed for current
computers can be extended to*

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exploit the unique power of quantum computers, which promise dramatic advantages in processing speed over currently available computer systems. Governments and industries around the globe are now investing vast amounts of

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money with the expectation of building practical quantum computers. Drawing upon years of experience and research in quantum computing research and using numerous examples and illustrations, Mingsheng Ying has

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created a very useful reference on quantum programming languages and important tools and techniques required for quantum programming, making the book a valuable resource for academics, researchers, and developers.

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Demystifies the theory of quantum programming using a step-by-step approach Covers the interdisciplinary nature of quantum programming by providing examples from many different fields including, engineering, computer

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*science, medicine, and life sciences
Includes techniques and tools to
solve complex control flow patterns
and synchronize computations
Presents a coherent and self-
contained treatment that will be
valuable for academics and*

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industrial researchers and developers

Takes students and researchers on a tour through some of the deepest ideas of maths, computer science and physics.

In the 1990's it was realized that

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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

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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

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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

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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

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subject to undergraduates and graduate students in computer science, mathematics, engineering, and physics, at Cornell University. An excellent introductory reference to quantum computing, this book provides a solid understanding of

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the basics of the theory and an awareness of the broad potential applicability of quantum computation. Includes a detailed overview of the historical context of quantum computing, discusses the most recent developments, and

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*presents interesting applications to
a number of areas from encryption
systems to database research.*

Quantum Machine Learning

Das schöpferische Teilchen

Grundlagen - Anwendungen -

Perspektiven

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*Elements of Quantum Computing
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IntroQuantum

**The multidisciplinary field
of quantum computing strives
to exploit some of the
uncanny aspects of quantum
mechanics to expand our**

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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

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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

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**computer science,
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theory, and hardware. The
text has step-by-step
examples, more than two
hundred exercises with
solutions, and programming
drills that bring the ideas**

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**of quantum computing alive
for today's computer science
students and researchers.
In quantum computing, we
witness an exciting and very
promising merge of two of
the deepest and most
successful scientific and**

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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

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**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**

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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

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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.

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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

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**professionals who have not
had training in quantum
computing or quantum
information theory,
including computer
scientists, programmers,
electrical engineers,
mathematicians, physics**

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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

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how to carry out
calculations with explicit
details and will gain a
fundamental grasp of: ***
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computation * Teleportation
* Quantum cryptography ***

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correction A number of
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so readers can see how
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with their own eyes, while
answers to similar end-of-**

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learn to master the
information. Ideal for
professionals and graduate-
level students alike,
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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. Since the 1980s research on quantum computation has

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dramatically changed the theoretical perspectives of computer science. Quantum computers could enable unprecedented computational power and revolutionize our cryptographic systems, even our entire electronic

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communication. This textbook gives an introduction to the theory of quantum computation. The author has chosen an elementary and lean theoretical approach, presupposing mathematical and physical knowledge which

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is standard in undergraduate courses of scientific or engineering studies, in essence linear algebra and complex numbers. The necessary mathematical notions are given in the appendix. Contents - Strange

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quantum world, qubits und
quantum gates - Quantum
Fourier transformation and
QFT algorithms - Quantum
search, quantum
communication, error
correcting quantum codes -
How to build and simulate a

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quantum logic Who should
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electronic engineering -
Students of computer**

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mathematics - Practitioners
in business and economy who
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technology**

Quantum Computation

Quantum Algorithm Animator

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Scientists
der Grundbaustein des
Universums
What Quantum Computing Means
to Data Mining**

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IN THE BEGINNING WAS THE BIT... The universe is made of bits of information and it has been known for more than a century that every piece of the the universe - every electron, atom and

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molecule - registers these bits and that information. It is only in the last years, however, with the discovery and development of quantum computers, that scientists have gained a

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**fundamental understanding
of just how that information
is registered and processed.
Building on recent
breakthroughs in quantum
computation, Seth Lloyd
shows how the universe**

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**itself is a giant computer.
Every atom and elementary
particle stores these bits,
and every collision between
those atoms and particles
flips the bits into a new
arrangement and**

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effortlessly spins out beautiful and complex systems, including galaxies, planets and life itself. But every computer needs a program, the set of instructions that tell it what

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**patterns to create. Where
did the bits come from that
tell the universe to create
its magnificent complexity?
Who - or what - is
programming the universe?
A quantum computer is a**

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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

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**quantum computing in the
1990's and some quantum
computers at the
experimental level were
recently implemented.
Quantum computers enable
super-speed computation**

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and can solve some important problems whose solutions were regarded impossible or intractable with traditional computers. This book provides a quick introduction to quantum

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computing for readers who have no backgrounds of both theory of computation and quantum mechanics. “Elements of Quantum Computing” presents the history, theories and

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engineering applications of quantum computing. The book is suitable to computer scientists, physicists and software engineers.

In this text we present a technical overview of the

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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

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**quantum computation and
computer science.**

**Specifically, our emphasis is
on the computational model
of quantum computing
rather than on the
engineering issues**

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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

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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

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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

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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

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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

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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

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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

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**Geometry / The Quantum
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/ Circuit Complexity Analysis
of Quantum Algorithms /
Conclusions / Bibliography
Quantum mechanics, the**

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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

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improve computational modeling of quantum systems, the field of quantum computing has recently garnered significant attention due to progress in building small-scale devices.

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However, significant technical advances will be required before a large-scale, practical quantum computer can be achieved.

**Quantum Computing:
Progress and Prospects**

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provides an introduction to the field, including the unique characteristics and constraints of the technology, and assesses the feasibility and implications of creating a

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functional quantum computer capable of addressing real-world problems. This report considers hardware and software requirements, quantum algorithms, drivers

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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

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success.

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Annotation International
computer scientists,
mathematicians, and physicists

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explore developments in the race to build a working quantum computer- -an effort that rests heavily on mathematical foundations. Contributors cover topics including quantum entanglement, universality of

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quantum gates, quantum search algorithms, quantum computational complexity, quantum error-correcting codes, algebraic and geometric structures, quantum teleportation, and secure communication and

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cryptography. The volume is intended for pure and applied mathematicians doing research on quantum computing as well as physicists and computer scientists who need to use algebra and mathematical analysis in working

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to develop quantum computers and information technology.

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This book presents leading-edge research in the field of computer science research including

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quantum computing, technology and applications. Each contribution has been carefully selected for inclusion based on the significance of the research to the field. Summaries of all chapters are gathered at the beginning of the

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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

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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

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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

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theoretically. Work with qubits, the fundamental elements of quantum computing. Discover what makes them different from classical bits. Model complex problems with logic gates specific to quantum computing. Learn how

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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.

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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

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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

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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

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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

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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.

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Katze

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Progress and Prospects

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A hands-on introduction to quantum computing and writing your own quantum programs with Python

The main focus of this textbook is the basic unit of information and

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*the way in which our
understanding of this
has evolved over time.
In particular the author
covers concepts related
to information,
classical computing,*

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*logic, reversible
computing, quantum
mechanics, quantum
computing,
thermodynamics and some
artificial intelligence
and biology, all*

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*approached from the
viewpoint of computer
sciences. The book
begins by asking the
following nontrivial
question: what is a bit?
The author then*

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discusses logic, logic gates, reversible computing and reversible architectures, and the concept of disorder. He then tries to establish the relationship between

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*three essential
questions that justify
quantum approaches in
computer sciences: the
energy required to
perform a real-life
computation, the size of*

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*current processors, and
the reversibility of
quantum operations.
Based on these concepts,
the author establishes
the conditions that
justify the use of*

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*quantum techniques for
certain kinds of
computational tasks, and
he uses formal
descriptions and formal
argumentations to
introduce key quantum*

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mechanical concepts and approaches. The rest of the book is formally different, focusing on practical issues, including a discussion of remarkable quantum

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*algorithms in a
treatment based on
quantum circuit theory.
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graduate students in
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students of other*

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disciplines who are engaged with physical models of information and computing.

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*devices. Unlike many
other texts, which tend
to emphasize algorithms,
Quantum Computing
Without Magic explains
the requisite quantum
physics in some depth,*

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and then explains the devices themselves. It is a book for readers who, having already encountered quantum algorithms, may ask, "Yes, I can see how the

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*algebra does the trick,
but how can we actually
do it?" By explaining
the details in the
context of the topics
covered, this book
strips the subject of*

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*the “magic” with which
it is so often cloaked.
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Without Magic covers the
essential probability
calculus; the qubit, its
physics, manipulation*

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*and measurement, and how
it can be implemented
using superconducting
electronics; quaternions
and density operator
formalism; unitary
formalism and its*

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applications and
implementations; and
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*quantum computing and
basic quantum mechanics,
or as an introduction
and guide for electronic
engineers,
mathematicians, computer
scientists, or scholars*

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in these fields who are interested in quantum computing and how it might fit into their research programs.

By the year 2020, the basic memory components

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*of a computer will be
the size of individual
atoms. At such scales,
the current theory of
computation will become
invalid. "Quantum
computing" is*

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*reinventing the
foundations of computer
science and information
theory in a way that is
consistent with quantum
physics - the most
accurate model of*

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*reality currently known.
Remarkably, this theory
predicts that quantum
computers can perform
certain tasks
breathhtakingly faster
than classical computers*

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*- and, better yet, can
accomplish mind-boggling
feats such as
teleporting information,
breaking supposedly
"unbreakable" codes,
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*numbers, and
communicating with
messages that betray the
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eavesdropping. This
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Explorations in Quantum Computing explains these burgeoning developments in simple terms, and describes the key technological hurdles that must be overcome to

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make quantum computers a reality. This easy-to-read, time-tested, and comprehensive textbook provides a fresh perspective on the capabilities of quantum

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*computers, and supplies
readers with the tools
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own foray into this
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and features: concludes
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*exercises and a summary
of the material covered;
provides an introduction
to the basic
mathematical formalism
of quantum computing,
and the quantum effects*

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*that can be harnessed
for non-classical
computation; discusses
the concepts of quantum
gates, entangling power,
quantum circuits,
quantum Fourier,*

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*wavelet, and cosine
transforms, and quantum
universality,
computability, and
complexity; examines the
potential applications
of quantum computers in*

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*areas such as search,
code-breaking, solving
NP-Complete problems,
quantum simulation,
quantum chemistry, and
mathematics;
investigates the uses of*

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*quantum information,
including quantum
teleportation,
superdense coding,
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compression, quantum
cloning, quantum*

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negation, and quantum cryptography; reviews the advancements made towards practical quantum computers, covering developments in quantum error correction

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advanced solar energy
company. Dr. Williams
has taught quantum
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Science at Stanford
University. He has spent
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Silicon Valley
companies. Today his
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cognitive computing,
computational material
design, visualization,
artificial intelligence,
evolutionary computing,*

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and remote olfaction. He was formerly a Research Scientist at Xerox PARC and a Research Assistant to Prof. Stephen W. Hawking, Cambridge University.

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*This textbook presents
the elementary aspects
of quantum computing in
a mathematical form. It
is intended as core or
supplementary reading
for physicists,*

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computer scientists
taking a first course on
quantum computing. It
starts by introducing
the basic mathematics
required for quantum*

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*mechanics, and then goes
on to present, in
detail, the notions of
quantum mechanics,
entanglement, quantum
gates, and quantum
algorithms, of which*

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Shor's factorisation and Grover's search algorithm are discussed extensively. In addition, the algorithms for the Abelian Hidden Subgroup and Discrete

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Logarithm problems are presented and the latter is used to show how the Bitcoin digital signature may be compromised. It also addresses the problem of

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error correction as well as giving a detailed exposition of adiabatic quantum computing. The book contains around 140 exercises for the student, covering all of

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*the topics treated,
together with an
appendix of solutions.
The Hardware, Software
and Heart of It
Adventures in Computer
Science*

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*Will We Ever Have a
Quantum Computer?
Quantum Computer
Systems: Research for
Noisy Intermediate-Scale
Quantum Computers
From Classical Bits to*

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Quantum Bits

An Introduction

This book targets computer scientists and engineers who are familiar with concepts in classical computer systems but are

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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

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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

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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

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programs, building a scalable software systems stack, and controlling quantum hardware components. Most chapters end with a summary and an outlook for future

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directions. This book celebrates the remarkable progress that scientists across disciplines have made in the past decades and reveals what roles computer scientists and

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engineers can play to enable practical-scale quantum computing.

Quantum computation, one of the latest joint ventures between physics and the theory of

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computation, is a scientific field whose main goals include the development of hardware and algorithms based on the quantum mechanical properties of those

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physical systems used to implement such algorithms. Solving difficult tasks (for example, the Satisfiability Problem and other NP-complete problems) requires the

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development of sophisticated algorithms, many of which employ stochastic processes as their mathematical basis. Discrete random walks are a popular choice among

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those stochastic processes. Inspired on the success of discrete random walks in algorithm development, quantum walks, an emerging field of quantum computation, is

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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

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Contents: Introduction /
Quantum Mechanics / Theory
of Computation / Classical
Random Walks / Quantum
Walks / Computer Science
and Quantum Walks /
Conclusions

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The design and development of quantum algorithms present a challenge, especially for inexperienced computer science students. Despite the numerous common

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concepts with classical computer science, quantum computation is still considered a branch of theoretical physics not commonly used by computer scientists. Experimental

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research into the development of a quantum computer makes the use of quantum mechanics in organizing computation more attractive, however the physical realization

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of a working quantum computer may still be decades away. This study introduces quantum computing to computer science students using a quantum algorithm animator

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called QuAL. QuAL's design uses features common to classical algorithm animators guided by an exploratory study but refined to animate the esoteric and interesting

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aspects of quantum algorithms. In addition, this study investigates the potential for the animation of a quantum sorting algorithm to help novice computer science

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students understand the formidable concepts of quantum computing. The animations focus on the concepts required to understand enough about quantum algorithms to

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entice student interest
and promote the
integration of quantum
computational concepts
into computer science
applications and
curricula. The

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experimental case study showed no significant improvement in student learning when using QuAL's initial prototype. Possible reasons include the animator's

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presentation of concepts and the study's pedagogical framework such as choice of algorithm (Wallace and Narayanan's sorting algorithm), design of pre- and post tests,

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and the study's small size (20 students) and brief duration (2 hours).

Nonetheless, the animation system was well received by students. Future work includes enhancing this

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animation tool for illustrating elusive concepts in quantum computing.

An accessible introduction to an exciting new area in computation, explaining

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such topics as qubits, entanglement, and quantum teleportation for the general reader. Quantum computing is a beautiful fusion of quantum physics and computer science,

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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

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introduction to quantum computing that is accessible to anyone who is comfortable with high school mathematics. He explains qubits, entanglement, quantum

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teleportation, quantum algorithms, and other quantum-related topics as clearly as possible for the general reader.

Bernhardt, a mathematician himself, simplifies the

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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

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of quantum computing, the qubit, and explains how the qubit can be measured; discusses entanglement—which, he says, is easier to describe mathematically

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than verbally—and what it means when two qubits are entangled (citing Einstein's characterization of what happens when the measurement of one

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entangled qubit affects the second as “spooky action at a distance”); and introduces quantum cryptography. He recaps standard topics in classical computing—bits,

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gates, and logic—and describes Edward Fredkin's ingenious billiard ball computer. He defines quantum gates, considers the speed of quantum algorithms, and describes

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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

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that quantum computing is the fundamental form of computing. The basic unit of computation is the qubit, not the bit.

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Mathematics of Quantum
Computing
Quantenphysik und
Wirklichkeit

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Devices

Quantenkryptografie,

Teleportation und

Quantencomputing

Once realized, the potential of large-scale quantum computers promises to radically transform computer

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science. Despite large-scale international efforts, however, essential questions about the potential of quantum algorithms are still unanswered. Automatic Quantum Computer Programming is an introduction both to quantum

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computing for non-physicists and 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

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descriptions of specific techniques, along with several examples of their human-competitive performance on specific problems.

This book provides you with a step-by-step introduction to quantum computing using the IBM Quantum

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Experience platform. You will learn how to build quantum programs on your own, discover early use cases in your business, and help to get you or your company equipped with quantum computing skills.

Computer Science: The Hardware,
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Software and Heart of It focuses on the deeper aspects of the two recognized subdivisions of Computer Science, Software and Hardware. These subdivisions are shown to be closely interrelated as a result of the stored-program

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concept. Computer Science: The Hardware, Software and Heart of It includes certain classical theoretical computer science topics such as Unsolvability (e.g. the halting problem) and Undecidability (e.g. Godel's incompleteness theorem)

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that treat problems that exist under the Church-Turing thesis of computation. These problem topics explain inherent limits lying at the heart of software, and in effect define boundaries beyond which computer science professionals

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cannot go beyond. Newer topics such as Cloud Computing are also covered in this book. After a survey of traditional programming languages (e.g. Fortran and C++), a new kind of computer Programming for

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parallel/distributed computing is presented using the message-passing paradigm which is at the heart of large clusters of computers. This leads to descriptions of current hardware platforms for large-scale computing, such as clusters of as

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many as one thousand which are the new generation of supercomputers. This also leads to a consideration of future quantum computers and a possible escape from the Church-Turing thesis to a new computation paradigm. The book's historical

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context is especially helpful during this, the centenary of Turing's birth. Alan Turing is widely regarded as the father of Computer Science, since many concepts in both the hardware and software of Computer Science can be traced to his

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pioneering research. Turing was a multi-faceted mathematician-engineer and was able to work on both concrete and abstract levels. This book shows how these two seemingly disparate aspects of Computer Science are intimately

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related. Further, the book treats the theoretical side of Computer Science as well, which also derives from Turing's research. Computer Science: The Hardware, Software and Heart of It is designed as a professional book for practitioners

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and researchers working in the related fields of Quantum Computing, Cloud Computing, Computer Networking, as well as non-scientist readers. Advanced-level and undergraduate students concentrating on computer science,

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engineering and mathematics will also find this book useful.

Ausgehend von der Theorie und den Protokollen der

Quantenkryptografie werden in dem Band die Servicequalitäten vorgestellt, die angesichts der

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aktuellen technischen Möglichkeiten erreichbar sind. Unter Berücksichtigung wenig beachteter Gesichtspunkte der Kryptoanalyse diskutiert der Autor die erreichbare Sicherheit und untersucht die Möglichkeiten des

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Quantencomputing. Anhand praxisnaher Aufgaben können Leser ihr Wissen vertiefen und lernen, die Techniken kritisch zu bewerten. Mit Programmieranleitung für Simulationsversuche auf dem eigenen Rechner.

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Explorations in Quantum
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Mathematics of Quantum
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An Introduction for Engineers and
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Quantum Computing Explained

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Programming The Universe
Computer Science and Quantum
Computing

Quantum Machine Learning bridges
the gap between abstract
developments in quantum computing
and the applied research on machine

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learning. Paring down the complexity of the disciplines involved, it focuses on providing a synthesis that explains the most important machine learning algorithms in a quantum framework. Theoretical advances in quantum computing are hard to follow for computer scientists, and sometimes

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even for researchers involved in the field. The lack of a step-by-step guide hampers the broader understanding of this emergent interdisciplinary body of research. Quantum Machine Learning sets the scene for a deeper understanding of the subject for readers of different backgrounds. The

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author has carefully constructed a clear comparison of classical learning algorithms and their quantum counterparts, thus making differences in computational complexity and learning performance apparent. This book synthesizes of a broad array of research into a manageable and

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concise presentation, with practical examples and applications. Bridges the gap between abstract developments in quantum computing with the applied research on machine learning Provides the theoretical minimum of machine learning, quantum mechanics, and quantum

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computing Gives step-by-step guidance to a broader understanding of this emergent interdisciplinary body of research

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

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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

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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

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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

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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

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dargestellt. Der Leser erfährt, was er von dieser Technologie erwarten kann und wo ihre Grenzen liegen. Das Besondere an dieser Einführung ist, dass keine speziellen Kenntnisse vorausgesetzt werden. Alle wichtigen Begriffe werden umfassend eingeführt, ein mathematischer Anhang stellt

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