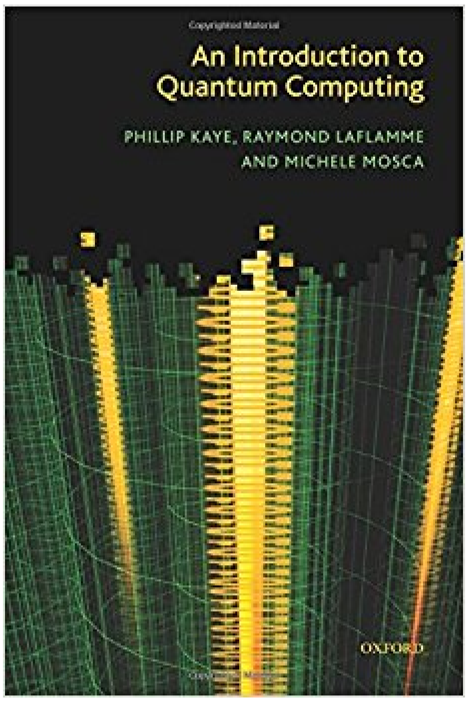
An Introduction To Quantum Computing



Synopsis

This concise, accessible text provides a thorough introduction to quantum computing - an exciting emergent field at the interface of the computer, engineering, mathematical and physical sciences. Aimed at advanced undergraduate and beginning graduate students in these disciplines, the text is technically detailed and is clearly illustrated throughout with diagrams and exercises. Some prior knowledge of linear algebra is assumed, including vector spaces and inner products. However, prior familiarity with topics such as tensor products and spectral decomposition is not required, as the necessary material is reviewed in the text.

Book Information

Paperback: 288 pages
Publisher: Oxford University Press; 1 edition (January 18, 2007)
Language: English
ISBN-10: 019857049X
ISBN-13: 978-0198570493
Product Dimensions: 9.1 x 0.6 x 6.1 inches
Shipping Weight: 15.5 ounces (View shipping rates and policies)
Average Customer Review: 4.2 out of 5 stars 9 customer reviews
Best Sellers Rank: #363,566 in Books (See Top 100 in Books) #28 inÂ Â Books > Computers & Technology > Hardware & DIY > Mainframes & Minicomputers #103 inÂ Â Books > Textbooks > Computer Science > Algorithms #194 inÂ Â Books > Textbooks > Science & Mathematics > Biology & Life Sciences > Botany

Customer Reviews

"The book is very accessible and the authors do an excellent job breaking up Shor’s factoring algorithm into pieces that students can easily digest." Jonathan R. Friedman, Physics Today"A reasonably brief and very accessible introductory graduate or senior undergraduate textbook."--Mathematical Reviews

Phillip Ronald Kaye was born in Toronto, and raised in Waterloo, Ontario, Canada. In 1995 Phil was accepted to the Faculty of Engineering at the University of Waterloo with an entrance scholarship. He completed his undergraduate degree in Systems Design Engineering in 2000 and was awarded the George Dufault Medal for Excellence in Communication at his convocation. During the Summer months following his undergraduate convocation, Phil worked as an encryption software developer at Research in Motion (RIM), where he continued to work on a part-time basis during his graduate studies. Phil did his Master's degree in the department of Combinatorics and Optimization at Waterloo. His Master's thesis was entitled 'Quantum Networks for Concentrating Entanglement, and a Logical Characterization of the Computational Complexity Class BPP.' Phil is currently a PhD student at the School of Computer Science at the University of Waterloo. Raymond Laflamme completed his undergraduate studies in Physics at UniversitÃƒÂ© Laval. He then moved to Cambridge, UK, where he took Part III of the Mathematical Tripos before doing a PhD in the Department of Applied Mathematics and Theoretical Physics (DAMTP) under the direction of Professor Stephen Hawking. Following posts at UBC, Cambridge and Los Alamos National Laboratory, Raymond moved to the University of Waterloo in 2001 as a Canada Research Chair in Quantum Information. Raymond is a recipient of Ontario's Premier Research Award and a Director of the Quantum Information program of the Canadian Institute for Advanced Research. He was named the Ivey Foundation Fellow of the Canadian Institute for Advanced Research (CIAR) in September of 2005. Michele Mosca obtained a DPhil in quantum computer algorithms in 1999 at the University of Oxford. Since then he has been a faculty member in Mathematics at St. Jerome's University and in the Combinatorics and Optimization department of the Faculty of Mathematics, University of Waterloo, and a member of the Centre for Applied Cryptographic Research. He holds a Premier's Research Excellence Award (2000-2005), is the Canada Research Chair in Quantum Computation (since January 2002), and is a CIAR scholar (since September 2003). He is a co-founder and the Deputy Director of the Institute for Quantum Computing, and a founding member of the Perimeter Institute for Theoretical Physics.

I would not call this an "introduction" despite the title. Instead, I would call this an excellent summary reference. It covers all the important topics, but very tersely -- and I've even found tidbits (like how to extend Simon's to an arbitrary subgroup) that are not even in the Mike & Ike QC/QI "bible." In general, it covers less material than Mike & Ike though.I tried to start with this text as an "introduction" but quickly discarded it, only to return to it now months later finding it a superb reference after learning the subject material from other books.

If you are attempting to enter the arena of quantum computation, and perhaps need a primer before tackling Nielsen and Chuang's standard text, then I would certainly consider this book. It conveys many of the illusive elements of quantum computation in an extremely clear and concise manner. When I first was getting into quantum computing, this book served as a Rosetta stone for many of the concepts that were at first foreign to me.Possessing a good knowledge of linear algebra, something that would be covered in a undergraduate course perhaps, is fairly important to ensure you get as much as you can out of reading this text. I’ve found this book to be an outstanding resource for learning many of the core concepts of quantum computation with an emphasis toward algorithm and circuit design.The layout of the book is as follows:1.) Introduction & Background:Here we obtain a high level view of the basics of quantum computation. Specific attention is given to various formulations of the Mach-Zehnder interferometer and how individual photons behave within this device. This lays the framework for the computational aspects related to quantum theory, and also develops enables the reader to develop an intuition early on for some of the topics ahead in the book.Preliminary concepts of computer science are also presented here with attention directed toward circuit diagrams, reversible computation, and matrix representations of computational gates.2.) Linear Algebra and the Dirac Notation:This section assumes the reader has a solid background in elementary linear algebra, and builds on top of those concepts. The Dirac notation formalism is presented and described incrementally with lots of good examples and explicit examples. One of the nice things about this book, is that it provides the reader with aThe book progresses to cover important linear algebraic concepts that are integral for comprehending the rest of the text. These include the spectral theorem, POVMs, tensor products, Schmidt decomposition, etc. Along the way, the authors provide examples (without the solutions unfortunately) to many problems to allow the reader to practice what they have read.3.) Qubits and the Framework of Quantum MechanicsThis chapter provides a gentle introduction into the notion of what a qubit is, and how one can visualize it via the Bloch sphere. It also covers how such an entity evolves through time, and how systems consisting of more than one qubit behave. I especially thought steady incline from classical to quantum notions of bit via the Bloch sphere was particularly lucid.This chapter also consists of the postulates of quantum mechanics presented in a computationally approachable manner. Some of the other mathematical necessities are also presented in this chapter, such as partial trace4.) A Quantum Model of ComputationHere, the prior notions are brought together to consider how one may perform computation on these entities. For instance, the classical/quantum gate and circuit models are compared and contrasted.5.) Superdense Coding and Quantum TeleportationThis chapter is fairly short, but delivers exactly what is says it will. The superdense protocol is conceptually introduced accompanied with an example. Following this is an explanation and application of quantum teleportation. The nice thing about this specific presentation is that a circuit model is pictorially represented for both protocols.6.) Introductory Quantum AlgorithmsHere the book considers some of the very well-known quantum algorithms in the literature. Specifically they cover, Deutsch's algorithm followed by the Deutsch-Jozsa and finally Simon's algorithm. This is a natural way that the majority of books approach presenting quantum algorithms since the difficulty level increases for each one.I personally like the treatment of the Deutsch-Jozsa algorithm compared to many others I've seen in other textbooks on quantum computing. It's accompanied by considering specific cases of the algorithm, which really brings everything into perspective. It was especially helpful to me when I was just starting out.7.) Algorithms with Superpolynomial Speed-upFor those especially interested in quantum algorithms, this chapter is of particular interest. They begin by providing the preliminary tools to approach this topic, quantum Fourier transform and quantum phase estimation, and proceed to a number of interesting algorithms. These range from eigenvalue estimation to the order-finding problem.8.) Algorithms Based on Amplitude AmplificationThe most famous quantum algorithm that manipulates amplitude amplification is Grover's algorithm, which is covered in this section. As one may assume from the title, the authors do go into more detail than most other accounts of Grover's algorithm on specifically how amplitude amplification plays a role in the algorithm.General quantum searching algorithms along with quantum counting are also briefly covered in the last few sections of the chapter.9.) Quantum Computation Complexity Theory and Lower BoundsFor those interested in the theoretical computer science aspects of quantum computing, this chapter serves as a very nice introduction. It is written in mind for someone who has had no prior exposure to such topics, and as a result introduces some of the notions of classical complexity theory before proceeding to the quantum case.The remainder of the chapter provides a nice overview of where certain problems are to be found in various complexity classes. The chapter is relatively brief, and does not go into a great amount of detail for someone who is more interested on the theoretical side of quantum computing. The chapter is still a very nice overview and synopsis.10.) Quantum Error CorrectionThe final chapter focuses on fault-tolerant quantum computation. The use and purpose of error-correcting codes are presented along with their quantum counterparts.Appendices:The appendices contain some further elaboration on the aforementioned topics such as ways to analyze probabilistic algorithms, distinguishing between two quantum states, etc.Overall, this is an exceptional introductory book on quantum computation. Emphasis is again, toward quantum algorithms and quantum circuits. I'd certainly recommend this text to anyone who wants to gain insight into the world of quantum computation. It has also served as a terrific reference source and is still today one of the best texts on the subject.

This book is geared for the reader who has an undergraduate education in a technical field and who has a solid background in linear algebra, including vector spaces and inner products. Prior familiarity with topics such as eigendecomposition and more advanced mathematical topics is not required. The book reviews all of the necessary additional material. There are some places in the book where group theory is referred to, but these sections of the book are self-contained so that the reader can skip them if needed. It is a very accessible introduction to a complex subject that is fairly detailed and complete. Exercises are integrated into the body of the text. Each exercise is designed to illustrate a particular concept, fill in the details of a calculation or proof, or to show how concepts in the book can be generalized or extended. The following is a brief overview of the book:1. Introduction and Background - Presents some fundamental notions of computation theory and quantum physics that will form the basis of what follows.2. Linear Algebra and the Dirac Notation - Familiarizes the reader with the algebraic notation used in quantum mechanics, reminds the reader of some basic facts about complex vector spaces, and introduces some notions that may not have been covered in an elementary linear algebra course.3. Qubits and the Framework of quantum Mechanics - Introduces the framework of quantum mechanics as it pertains to the types of systems that are considered in the book. Here the author also introduces the notion of a quantum bit or "qubit", which is a fundamental concept in quantum computing.4. A Quantum Model of Computation - The circuit model of classical computation can be generalized to a model of quantum circuits. In such a model you have logical qubits carried along "wires" and quantum gates that act on the qubits. For convenience, the discussion is limited to unitary quantum gates.5. Superdense Coding and Quantum Teleportation - Looks at our first protocols for quantum information. Examines two communication protocols that can be implemented using the tools which can be implemented using the tools developed in previous chapters. These protocols are known as superdense coding and quantum teleportation. Both of these are inherently quantum - there are no classical protocols that behave in the same way as these.6. Introductory Quantum Algorithms - Describes some of the early quantum algorithms that are simple and illustrate the main ingredients behind the more useful and powerful quantum algorithms described in subsequent chapters. Since quantum algorithms share some features with classical probabilistic algorithms, the chapter starts with a comparison of the two algorithmic paradigms.7. Algorithms with Superpolynomial Speed-Up - Examines one of two main classes of algorithms: quantum algorithms that solve problems with a complexity that is superpolynomially less than the complexity of the best-known classical algorithm for the same problem. That is, the complexity of the best-known classical algorithm cannot be bounded above by any poynomial in the complexity of the quantum algorithm. The chapter starts off by studying the problem of quantum phase estimation, which leads naturally to the Quantum Fourier Transform (QFT).8. Algorithms Based on Amplitude Amplification - Discusses a broadly applicable quantum algorithm - quantum search - that provides a polynomial speed-up over the best-known classical algorithms for a wide class of important problems.9. Quantum Computational Complexity Theory and Lower Bounds - Quantum computers seem to be more powerful than classical computers for certain problems. However, there are limits on the power of quantum computers. Since a classical computer can simulate a quantum one, a quantum computer can only compute the same set of functions that a classical computer can. This chapter examines this and some related issues.10. Quantum Error Correction - Quantum computers are more susceptible to errors than classical digital computers because quantum mechanical systems are more delicate and more difficult to control. If large-scale quantum computers are to be possible, a theory of quantum error correction is needed. This is the issue discussed in this chapter.Overall, I found this book well suited to self-study, particularly for someone with an engineering background. Highly recommended.

So far so good; I think it covers all the basics. The first two chapters will review almost all the information you need from Math, Physics and Computer Science. Having a good understanding of how quantum systems work will definitely help.

great resource ...I never depend on a single book to learn a subject on my own ...I recommned the one by Mermin and the one by Rieffel

The book certainly gives a nice and gentle introduction. But about half through it, I become more and more disappointed:- It is often not clear which theorems and statements are proved and what is merely cited from the literature. This isn’t a problem at the beginning, but becomes a source of confusion in the second half of the book.- There is a large bibliography, but as far as I could see, it is very seldom referenced where it would make most sense.- Some statements are really careless. Many algorithms talk about registers without even specifying them. E.g. Simon’s algorithm.

(Cambridge Monographs on Mathematical Physics) Quantum Ontology: A Guide to the Metaphysics of Quantum Mechanics Quantum Mechanics: Re-engineering Your Life With Quantum Mechanics & Affirmations Quantum Runes: How to Create Your Perfect Reality Using Quantum Physics and Teutonic Rune Magic (Creating Magick with The Universal Laws of Attraction Book 1) Delirious, A Quantum Novel (Quantum Series Book 6) Quantum Thermodynamics: Emergence of Thermodynamic Behavior Within Composite Quantum Systems (Lecture Notes in Physics) The Quantum Mechanics Solver: How to Apply Quantum Theory to Modern Physics Quantum Space (Quantum Series Book 1) Quantum Incident (Quantum Series Book 0) Introduction to Probability and Statistics: Principles and Applications for Engineering and the Computing Sciences Introduction to Computing Systems: From Bits and Gates to C and Beyond Introduction to Scientific and Technical Computing Introduction to High Performance Computing for Scientists and Engineers (Chapman & Hall/CRC Computational Science) An Introduction to Scientific Computing: Twelve Computational Projects Solved with MATLAB (Texts in Applied Mathematics)