



Quantum Computing

Lecture 1: Basic Introduction

"The laws of physics present no barrier to reducing the size of computers until bits are the size of atoms"

— Richard P. Feynman (1985)

Mountain View CA, July 28, 2020

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An Introduction To Quantum Computing

Chris Bernhardt



An Introduction To Quantum Computing:

An Introduction to Quantum Computing Phillip Kaye, Raymond Laflamme, Michele Mosca, 2007 The authors provide an introduction to quantum computing Aimed at advanced undergraduate and beginning graduate students in these disciplines this text is illustrated with diagrams and exercises [Introduction to Quantum Computing](#) Ray LaPierre, 2021-09-27 This book provides a self contained undergraduate course on quantum computing based on classroom tested lecture notes It reviews the fundamentals of quantum mechanics from the double slit experiment to entanglement before progressing to the basics of qubits quantum gates quantum circuits quantum key distribution and some of the famous quantum algorithms As well as covering quantum gates in depth it also describes promising platforms for their physical implementation along with error correction and topological quantum computing With quantum computing expanding rapidly in the private sector understanding quantum computing has never been so important for graduates entering the workplace or PhD programs Assuming minimal background knowledge this book is highly accessible with rigorous step by step explanations of the principles behind quantum computation further reading and end of chapter exercises ensuring that undergraduate students in physics and engineering emerge well prepared for the future *An Introduction to Quantum Computing Algorithms* Arthur O. Pittenger, 2012-12-06 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 computer Since the difficulty of the factoring problem is crucial for the security of a public key encryption system interest and funding in quantum computing and quantum computation suddenly blossomed Quantum computing had arrived The study of the role of quantum mechanics in the theory of computation seems to have begun in the early 1980s with the publications of Paul Benioff 67 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 perspective 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 [Quantum Computer Science](#) N. David Mermin, 2007-08-30 In the 1990s 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 Quantum Computing Eleanor G. Rieffel, Wolfgang H. Polak, 2014-08-29 A thorough exposition of quantum computing and the underlying concepts of quantum physics with explanations of the relevant mathematics and numerous examples The combination of two of the twentieth century's most influential and revolutionary scientific theories information theory and quantum mechanics gave rise to a radically new view of computing and information Quantum information processing explores the implications of using quantum mechanics instead of classical mechanics to model information and its processing Quantum computing is not about changing the physical substrate on which computation is done from classical to quantum but about changing the notion of computation itself at the most basic level The fundamental unit of computation is no longer the bit but the quantum bit or qubit This comprehensive introduction to the field offers a thorough exposition of quantum computing and the underlying concepts of quantum physics explaining all the relevant mathematics and offering numerous examples With its careful development of concepts and thorough explanations the book makes quantum computing accessible to students and professionals in mathematics computer science and engineering A reader with no prior knowledge of quantum physics but with sufficient knowledge of linear algebra will be able to gain a fluent understanding by working through the book

Introduction To Quantum Computers Gennady P Berman, Gary D Doolen, Ronnie Mainieri, Vladimir I Tsifrinovich, 1998-07-07 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 **An Introduction to Quantum Computing for Computer Engineers** Marcus Stephen Edwards, 2026-03-14 This book focuses on practical topics in quantum computing that will give a student or practitioner of computer engineering a foundational understanding of quantum computer engineering The reader should know enough by the end of the book to work effectively with quantum computers in a lab or industry setting at any layer of the stack Provides readers with a working knowledge of quantum mechanics without the need to read comprehensive textbooks Includes prerequisite knowledge needed to begin working on any part of the quantum computing stack Teaches useful skills throughout the book such as nanofabrication programming PCB design and RF circuit design **Quantum Computing for Everyone** Chris Bernhardt, 2019-03-19 An accessible introduction to an exciting new area in computation explaining such topics as qubits entanglement and quantum

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

Introduction to Quantum Computing Hiu Yung Wong, 2022-05-24 This textbook introduces quantum computing to readers who do not have much background in linear algebra The author targets undergraduate and master students as well as non CS and non EE students who are willing to spend about 60-90 hours seriously learning quantum computing Readers will be able to write their program to simulate quantum computing algorithms and run on real quantum computers on IBM Q Moreover unlike the books that only give superficial hand waving explanations this book uses exact formalism so readers can continue to pursue more advanced topics based on what they learn from this book Encourages students to embrace uncertainty over the daily classical experience when encountering quantum phenomena Uses narrative to start each section with analogies that help students to grasp the critical concept quickly Uses numerical substitutions accompanied by Python programming and IBM Q quantum computer programming as examples in teaching all critical concepts

[A Short Introduction to Quantum Information and Quantum Computation](#) Michel Le Bellac, 2006-06-15 Quantum information and computation is a rapidly expanding and cross disciplinary subject This book first published in 2006 gives a self contained introduction to the field for physicists mathematicians and computer scientists who want to know more about this exciting subject After a step by step introduction to the quantum bit qubit and its main properties the author presents the necessary background in quantum mechanics The core of the subject quantum computation is illustrated by a detailed treatment of three quantum algorithms Deutsch Grover and Shor The final chapters are devoted to the physical implementation of quantum computers including the most recent aspects such as superconducting qubits and quantum dots and to a short account of quantum information

Written at a level suitable for undergraduates in physical sciences no previous knowledge of quantum mechanics is assumed and only elementary notions of physics are required The book includes many short exercises with solutions available to instructors through solutions cambridge org

All You Need to Know About Quantum Computing Hebooks, All You Need to Know About Quantum Computing An Introduction to Classical and Quantum Computation for Beginners is your ultimate guide to understanding the fascinating world of quantum computing Designed for beginners this book provides a clear and concise explanation of both classical and quantum computation starting from the very basics and progressing to more advanced concepts Whether you re a student professional or simply curious about the future of computing this book breaks down complex topics like quantum mechanics quantum algorithms and quantum programming into easy to understand language Inside you ll discover the key principles behind quantum computing such as qubits superposition and entanglement and how they differ from classical computing s bits and operations The book also explores the applications of quantum computing across various industries from cryptography and artificial intelligence to drug discovery and climate modeling You ll gain insights into the challenges quantum computing faces today as well as the exciting potential it holds for the future With practical examples step by step tutorials on quantum programming platforms and resources for further learning this book equips you with the knowledge and tools you need to begin your quantum computing journey Whether you re looking to build a career in quantum tech or simply want to understand the technology that could revolutionize the world All You Need to Know About Quantum Computing is the perfect starting point

Mathematics of Quantum Computing Wolfgang Scherer,2019-11-13 This textbook presents the elementary aspects of quantum computing in a mathematical form It is intended as core or supplementary reading for physicists mathematicians and computer scientists taking a first course on quantum computing It starts by introducing the basic mathematics required for quantum mechanics and then goes on to present in detail the notions of quantum mechanics entanglement quantum gates and quantum algorithms of which Shor s factorisation and Grover s search algorithm are discussed extensively In addition the algorithms for the Abelian Hidden Subgroup and Discrete 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 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 the topics treated together with an appendix of solutions

Introduction to Quantum Computing with Q# and QDK Filip Wojcieszyn,2022-05-07 This book introduces the fundamentals of the theory of quantum computing illustrated with code samples written in Q a quantum specific programming language and its related Quantum Development Kit Quantum computing QC is a multidisciplinary field that sits at the intersection of quantum physics quantum information theory computer science and mathematics and which may revolutionize the world of computing and software engineering The book begins by covering historical aspects of quantum theory and quantum computing as well as offers a gentle algebra based introduction to quantum mechanics

specifically focusing on concepts essential for the field of quantum programming Quantum state description state evolution quantum measurement and the Bell's theorem are among the topics covered The readers also get a tour of the features of QDK and familiarize themselves with the QDK Next the core QC topics are discussed complete with the necessary mathematical formalism This includes the notions of qubit quantum gates and quantum circuits In addition to that the book provides a detailed treatment of a series of important concepts from quantum information theory in particular entanglement and the no-cloning theorem followed by discussion about quantum key distribution and its various protocols Finally the canon of most important QC algorithms and algorithmic techniques is covered in depth from the Deutsch-Jozsa algorithm through Grover's search to Quantum Fourier Transform quantum phase estimation and Shor's algorithm The book is an accessible introduction into the vibrant and fascinating field of quantum computing offering a blend of academic diligence with pragmatism that is so central to software development world All of the discussed theoretical aspects of QC are accompanied by runnable code examples providing the reader with two different angles mathematical and programmatic of looking at the same problem space

Introduction to Quantum Computation Ioan Burda, 2005 Introduction to Quantum Computation is an introduction to a new rapidly developing theory of quantum computing The book is a comprehensive introduction to the main ideas and techniques of quantum computation It begins with the basics of classical theory of computation NP-complete problems Boolean circuits Finite state machine Turing machine and the idea of complexity of an algorithm The general quantum formalism pure states qubit superposition evolution of quantum system entanglement multi-qubit system and complex algorithm examples are also presented Matlab is a well-known in engineer academia as matrix computing environment which makes it well suited for simulating quantum algorithms The Quantum Computer Toolbox (QCT) is written entirely in the Matlab and m-files are listed in book's sections There are certain data types that are implicitly defined by the QCT including data types for qubit registers and transformations The QCT contains many functions designed to mimic the actions of a quantum computer In addition the QCT contains several convenience functions designed to aid in the creation and modification of the data types used in algorithms The main purposes of the QCT are for research involving Quantum Computation and as a teaching tool to aid in learning about Quantum Computing systems The readers will learn to implement complex quantum algorithm quantum teleportation and Deutsch-Grover-Shor algorithm under Matlab environment complete Matlab code examples

A First Introduction to Quantum Computing and Information Bernard Zygelman, 2018-09-21 This book addresses and introduces new developments in the field of Quantum Information and Computing (QIC) for a primary audience of undergraduate students Developments over the past few decades have spurred the need for QIC courseware at major research institutions This book broadens the exposure of QIC science to the undergraduate market The subject matter is introduced in such a way so that it is accessible to students with only a first-year calculus background Greater accessibility allows a broader range of academic offerings Courses based on this book could be offered in the Physics Engineering Math

and Computer Science departments This textbook incorporates Mathematica based examples into the book In this way students are allowed a hands on experience in which difficult abstract concepts are actualized by simulations The students can turn knobs in parameter space and explore how the system under study responds The incorporation of symbolic manipulation software into course ware allows a more holistic approach to the teaching of difficult concepts Mathematica software is used here because it is easy to use and allows a fast learning curve for students who have limited experience with scientific programming

An Introduction to Quantum Computing Anya Bindra, Quantum computing is an emerging technology with the power to bring new breakthroughs in the fields of science and can complement and make existing technologies such as machine learning more powerful Today there are certain challenges that classical computing is not able to solve such as the factoring integers problem which is considered an NP problem but can easily be cracked using Shor s algorithm In this textbook we will explore how quantum computers use the principles of superposition and entanglement as their foundations and harness the power of Bloch Spheres to represent states of a qubit An introduction to quantum computing with Qiskit begins with developing the linear algebra and quantum mechanics that are key to understanding quantum computing Then the basics of coding quantum circuits and quantum logic gates will be introduced and several exciting algorithms such as quantum cryptography algorithms will be implemented on Qiskit Quantum Information Science Kit

Quantum Computing in the Arts and Humanities Eduardo Reck Miranda,2022-05-05 Computers are essential for the functioning of our society Despite the incredible power of existing computers computing technology is progressing beyond today s conventional models Quantum Computing QC is surfacing as a promising disruptive technology QC is built on the principles of quantum mechanics QC can run algorithms that are not trivial to run on digital computers QC systems are being developed for the discovery of new materials and drugs and improved methods for encoding information for secure communication over the Internet Unprecedented new uses for this technology are bound to emerge from ongoing research The development of conventional digital computing technology for the arts and humanities has been progressing in tandem with the evolution of computers since the 1950s Today computers are absolutely essential for the arts and humanities Therefore future developments in QC are most likely to impact on the way in which artists will create and perform and how research in the humanities will be conducted This book presents a comprehensive collection of chapters by pioneers of emerging interdisciplinary research at the crossroads of quantum computing and the arts and humanities from philosophy and social sciences to visual arts and music Prof Eduardo Reck Miranda is a composer and a professor in Computer Music at Plymouth University UK where he is a director of the Interdisciplinary Centre for Computer Music Research ICCMR His previous publications include the Springer titles Handbook of Artificial Intelligence for Music Guide to Unconventional Computing for Music Guide to Brain Computer Music Interfacing and Guide to Computing for Expressive Music Performance

Introduction to Quantum Computation and Information Hoi-Kwong Lo,Tim Spiller,Sandu Popescu,1998 The book fills a

gap between the turgid prose of the burgeoning research literature and the superficial accounts in the popular press Nature 1999 The concepts introduced in this book and the forecast of future directions provided should continue to provide a good primer for the exciting breakthrough anticipated in this field Mathematics Abstracts 2001 Despite its age this book remains an excellent way to learn the basics of quantum information Quantum Information and Computation 2002

Explorations in Quantum Computing Colin P. Williams, 2010-12-07 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 **Introduction to Quantum Algorithms via Linear Algebra, second edition** Richard J. Lipton, Kenneth W. Regan, 2021-04-06 Quantum computing explained in terms of elementary linear algebra emphasizing computation and algorithms and requiring no background in physics This introduction to quantum algorithms is concise but comprehensive covering many key algorithms It is mathematically rigorous but requires minimal background and assumes no knowledge of quantum theory or quantum mechanics The book explains quantum computation in terms of elementary linear algebra it assumes the reader will have some familiarity with vectors matrices and their basic properties but offers a review of the relevant material from linear algebra By emphasizing computation and algorithms rather than physics it makes quantum algorithms accessible to students and researchers in computer science who have not taken courses in quantum physics or delved into fine details of quantum effects apparatus circuits or theory

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