

COMPUTATIONAL MATHEMATICS SERIES

MATHEMATICS of QUANTUM COMPUTATION



Edited by
Ranee K. Brylinski
Goong Chen



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Mathematics Of Quantum Computation Computational Mathematics

Wolfgang Scherer



Mathematics Of Quantum Computation Computational Mathematics:

Mathematics of Quantum Computation Ranee K. Brylinski, Goong Chen, 2002-02-14 Among the most exciting 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 quantum computer science Mathematics of Quantum Computation brings together leading computer science and mathematics researchers to present a comprehensive treatment of the field **Mathematics of Quantum Computation and Quantum Technology** Louis Kauffman, Samuel J. Lomonaco, 2007-09-19 Research and development in the pioneering field of quantum computing involve just about every facet of science and engineering including the significant areas of mathematics and physics Based on the firm understanding that mathematics and physics are equal partners in the continuing study of quantum science Mathematics of Quantum Computation and Quantum Technology presents a comprehensive treatment of the field **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 **Essential Mathematics for Quantum Computing** Leonard S. Woody III, 2022-04-22 Demystify quantum computing by learning the math it is built on Key Features Build a solid mathematical foundation to get started with developing powerful quantum solutions Understand linear algebra calculus matrices complex numbers vector spaces and other concepts essential for quantum computing Learn the math needed to understand how quantum algorithms function Book Description Quantum computing is an exciting subject that offers hope to solve the world's most complex problems at a quicker pace It is being used quite widely in different spheres of technology including cybersecurity finance and many more but its concepts such as superposition are often misunderstood because engineers may not know the math to understand them This book will teach the requisite math concepts in an intuitive way and connect them to principles in quantum computing Starting with the most basic of concepts 2D vectors that are just line segments in space you'll move on to tackle matrix multiplication using an instinctive method Linearity is the major theme throughout the book and since quantum mechanics is a linear theory you'll see how they go hand in hand As you advance you'll understand intrinsically what a vector is and how to transform vectors with matrices and operators You'll also see how complex numbers make their voices heard and understand the probability behind it all It's all here in writing you can understand This is not a stuffy math book with

definitions axioms theorems and so on This book meets you where you are at and guides you to where you need to be for quantum computing Already know some of this stuff No problem The book is componentized so you can learn just the parts you want And with tons of exercises and their answers you'll get all the practice you need What you will learn Operate on vectors qubits with matrices gates Define linear combinations and linear independence Understand vector spaces and their basis sets Rotate reflect and project vectors with matrices Realize the connection between complex numbers and the Bloch sphere Determine whether a matrix is invertible and find its eigenvalues Probabilistically determine the measurement of a qubit Tie it all together with bra ket notation Who this book is for If you want to learn quantum computing but are unsure of the math involved this book is for you If you've taken high school math you'll easily understand the topics covered And even if you haven't the book will give you a refresher on topics such as trigonometry matrices and vectors This book will help you gain the confidence to fully understand quantum computation without losing you in the process

Computing Mathematics
Barrett Williams, ChatGPT, 2025-05-13 Step into the captivating world of Computing Mathematics a journey where the timeless elegance of mathematics meets the cutting edge realm of modern computing This eBook takes you through a meticulously curated exploration of the indispensable mathematical concepts and frameworks that drive today's technological advancements Begin by unraveling the intriguing Foundations of Mathematical Computation a section that lays the groundwork with historical insights and essential theories Dive into the birth of algorithmic thinking encountering groundbreaking ideas that shaped the digital landscape from Alan Turing's pioneering work to contemporary algorithm design and efficiency Navigate through Numerical Methods in Computing and witness how equations and approximations fuel computational processes across various industries Discover the power of cryptography in securing global communication understanding both the elegance of mathematical encryption and complex cryptographic protocols Venture into the realm of Machine Learning and Statistical Methods where algorithms and neural networks underpin the revolution in artificial intelligence Explore graph theory's pivotal role in mapping social networks and network analysis offering fresh perspectives on connectivity and innovation With a keen eye on future possibilities the section on Quantum Computing invites you to imagine a novel computational paradigm uniting quantum mechanics with algorithmic brilliance Delve into the unpredictable world of chaos theory learning its applications in predictive models and beyond The eBook also shines a light on the vast potential of Big Data and Data Science offering insights into mathematical tools that decode the complexities of data driven industries Traverse through the intricate geometry in computational graphics and the foundational theories that anchor distributed systems and blockchain technologies Conclude your expedition with Future Directions a visionary glance at the evolving nexus between mathematics and computing where emerging trends and ethical considerations signal the next wave of innovation Computing Mathematics is your gateway to understanding the mathematical heartbeat of the digital age a must read for anyone poised to embrace the future of technology

Elements of Quantum Computation and Quantum

Communication Anirban Pathak, 2013-06-20 While there are many available textbooks on quantum information theory most are either too technical for beginners or not complete enough Filling the gap this book gives a clear self contained introduction to quantum computation and communication Exploring recent developments and open questions in the field it prepares readers for further study and helps them understand more advanced texts and journal papers Along with thought provoking cartoons and brief biographies of key players in the field each chapter includes examples references exercises and problems with detailed solutions

Computational Mathematics Dimitrios Mitsotakis, 2023-06-19 This textbook is a comprehensive introduction to computational mathematics and scientific computing suitable for undergraduate and postgraduate courses It presents both practical and theoretical aspects of the subject as well as advantages and pitfalls of classical numerical methods alongside with computer code and experiments in Python Each chapter closes with modern applications in physics engineering and computer science Features No previous experience in Python is required Includes simplified computer code for fast paced learning and transferable skills development Includes practical problems ideal for project assignments and distance learning Presents both intuitive and rigorous faces of modern scientific computing Provides an introduction to neural networks and machine learning

Quantum Computation Samuel J. Lomonaco, This book presents written versions of the eight lectures given during the AMS Short Course held at the Joint Mathematics Meetings in Washington D C The objective of this course was to share with the scientific community the many exciting mathematical challenges arising from the new field of quantum computation and quantum information science The course was geared toward demonstrating the great breadth and depth of this mathematically rich research field Interrelationships with existing mathematical research areas were emphasized as much as possible Moreover the course was designed so that participants with little background in quantum mechanics would upon completion be prepared to begin reading the research literature on quantum computation and quantum information science Based on audience feedback and questions the written versions of the lectures have been greatly expanded and supplementary material has been added The book features an overview of relevant parts of quantum mechanics with an introduction to quantum computation including many potential quantum mechanical computing devices introduction to quantum algorithms and quantum complexity theory in depth discussion on quantum error correcting codes and quantum cryptography and finally exploration into diverse connections between quantum computation and various areas of mathematics and physics This book is the companion volume to *Quantum Computation and Quantum Information* CONM 305 Volume 305 in the Contemporary Mathematics series

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 [6, 7] who considered a quantum mechanical model of computers and the computation process A related question was discussed shortly thereafter by Richard Feynman [35] who began from a different 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

Concise Guide to Quantum Computing

Sergei Kurgalin, Sergei Borzunov, 2021-02-24 This textbook is intended for practical laboratory sessions associated with the course of quantum computing and quantum algorithms as well as for self study It contains basic theoretical concepts and methods for solving basic types of problems and gives an overview of basic qubit operations entangled states quantum circuits implementing functions quantum Fourier transform phase estimation etc The book serves as a basis for the application of new information technologies in education and corporate technical training theoretical material and examples of practical problems as well as exercises with in most cases detailed solutions have relation to information technologies A large number of detailed examples serve to better develop professional competencies in computer science

Classical and Quantum Computation

Alexei Yu. Kitaev, Alexander Shen, Mikhail N. Vyalyi, 2002 This book is an introduction to a new rapidly developing theory of quantum computing It begins with the basics of classical theory of computation Turing machines Boolean circuits parallel algorithms probabilistic computation NP complete problems and the idea of complexity of an algorithm The second part of the book provides an exposition of quantum computation theory It starts with the introduction of general quantum formalism pure states density matrices and superoperators universal gate sets and approximation theorems Then the authors study various quantum computation algorithms Grover's algorithm Shor's factoring algorithm and the Abelian hidden subgroup problem In concluding sections several related topics are discussed parallel quantum computation a quantum analog of NP completeness and quantum error correcting codes Rapid development of quantum computing started in 1994 with a stunning suggestion by Peter Shor to use quantum computation for factoring large numbers an extremely difficult and time consuming problem when using a conventional computer Shor's result spawned a burst of activity in designing new algorithms and in attempting to actually build quantum computers Currently the progress is much more significant in the former a sound theoretical basis of quantum computing is under development and many algorithms have been suggested In this concise text the authors provide solid foundations to the theory in particular a careful analysis of the quantum circuit model and cover selected topics in depth Included are a complete proof of the Solovay Kitaev theorem with accurate algorithm complexity bounds approximation of unitary operators by circuits of doubly logarithmic depth Among other interesting topics are toric codes and their relation to the anyon approach to quantum computing Prerequisites are very modest and include linear algebra elements of group theory and probability and the notion of a formal or an intuitive algorithm This text is suitable for a course in quantum computation for graduate students in mathematics

physics or computer science More than 100 problems most of them with complete solutions and an appendix summarizing the necessary results are a very useful addition to the book It is available in both hardcover and softcover editions

Foundations of Computational Mathematics, Minneapolis 2002 Felipe Cucker,2004-03-25 The Foundations of Computational Mathematics meetings are a platform for cross fertilization between numerical analysis mathematics and computer science This volume first published in 2004 contains the plenary presentations given by some of the leading authorities in the world and topics surveyed range from optimization to computer algebra image processing to differential equations quantum complexity to geometry The volume will be essential reading for all those wishing to be informed of the state of the art in computational mathematics

Mathematical Foundations of Computer Science 2001 Ales Pultr,2001-08-15 This book constitutes the refereed proceedings of the 26th International Symposium on Mathematical Foundations of Computer Science MFCS 2001 held in Mariánské Lázně Czech Republic in August 2001 The 51 revised full papers presented together with 10 invited contributions were carefully reviewed and selected from a total of 118 submissions All current aspects of theoretical computer science are addressed ranging from mathematical logic and programming theory to algorithms discrete mathematics and complexity theory Besides classical issues modern topics like quantum computing are discussed as well

Mathematical Foundations of Computer Science 2001 Jiri Sgall,Ales Pultr,Petr Kolman,2003-08-06 This book constitutes the refereed proceedings of the 26th International Symposium on Mathematical Foundations of Computer Science MFCS 2001 held in Mariánské Lázně Czech Republic in August 2001 The 51 revised full papers presented together with 10 invited contributions were carefully reviewed and selected from a total of 118 submissions All current aspects of theoretical computer science are addressed ranging from mathematical logic and programming theory to algorithms discrete mathematics and complexity theory Besides classical issues modern topics like quantum computing are discussed as well

Mathematical Foundations of Computer Science 1995 Juraj Wiedermann,1995-08-16 This book presents the proceedings of the 20th International Symposium on Mathematical Foundations of Computer Science MFCS 95 held in Prague Czech Republic in August September 1995 The book contains eight invited papers and two abstracts of invited talks by outstanding scientists as well as 44 revised full research papers selected from a total of 104 submissions All relevant aspects of theoretical computer science are addressed particularly the mathematical foundations the papers are organized in sections on structural complexity algorithms complexity theory graphs in models of computation lower bounds formal languages unification rewriting and type theory distributed computation concurrency semantics model checking and formal calculi

Mathematics for Future Computing and Communications Liao Heng,Bill McColl,2021-12-16 A panorama of new ideas in mathematics that are driving innovation in computing and communications

Classical and Quantum Computing Yorick Hardy,Willi H. Steeb,2012-12-06 Classical and Quantum computing provides a self contained systematic and comprehensive introduction to all the subjects and techniques important in scientific computing The style and

presentation are readily accessible to undergraduates and graduates A large number of examples accompanied by complete C and Java code wherever possible cover every topic Features and benefits Comprehensive coverage of the theory with many examples Topics in classical computing include boolean algebra gates circuits latches error detection and correction neural networks Turing machines cryptography genetic algorithms For the first time genetic expression programming is presented in a textbook Topics in quantum computing include mathematical foundations quantum algorithms quantum information theory hardware used in quantum computing This book serves as a textbook for courses in scientific computing and is also very suitable for self study Students professionals and practitioners in computer science applied mathematics and physics will benefit from using the book and the included software simulations *Mathematical Methods in Computer Science* Jacques Calmet, Willi Geiselmann, Jörn Müller-Quade, 2008-12-10 This Festschrift volume contains the proceedings of the conference Mathematical Methods in Computer Science MMICS 2008 held December 2008 in Karlsruhe Germany in memory of Thomas Beth The themes of the conference reflect his many interests Advances in Mathematical and Computational Sciences Manoj Kumar Patel, Triloki Nath, Ram Kishor Pandey, Diwakar Shukla, 2024-11-04 This volume documents the contributions presented at The ICRTMPCS II International Conference on Advances in Mathematical and Computational Sciences Entries focus on modern trends and techniques in branches of pure and applied mathematics statistics and computer science Highlighting applications in coding theory cryptography graph theory fuzzy theory variance analysis data analysis and sampling theory Topological Quantum Computation Zhenghan Wang, 2010 Topological quantum computation is a computational paradigm based on topological phases of matter which are governed by topological quantum field theories In this approach information is stored in the lowest energy states of many anyon systems and processed by braiding non abelian anyons The computational answer is accessed by bringing anyons together and observing the result Besides its theoretical esthetic appeal the practical merit of the topological approach lies in its error minimizing hypothetical hardware topological phases of matter are fault avoiding or deaf to most local noises and unitary gates are implemented with exponential accuracy Experimental realizations are pursued in systems such as fractional quantum Hall liquids and topological insulators This book expands on the author's CBMS lectures on knots and topological quantum computing and is intended as a primer for mathematically inclined graduate students With an emphasis on introducing basic notions and current research this book gives the first coherent account of the field covering a wide range of topics Temperley Lieb Jones theory the quantum circuit model ribbon fusion category theory topological quantum field theory anyon theory additive approximation of the Jones polynomial anyonic quantum computing models and mathematical models of topological phases of matter

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