

CONTENTS

Front Matter

- Preface
- Acknowledgments

PART I: FOUNDATIONS OF QUANTUM COMPUTING

Chapter 1: Introduction to Quantum Computing	1-16
• 1.1 Motivation and Historical Background	
• 1.2 Classical vs Quantum Computing	
• 1.3 Applications in Engineering and Data Science	
• 1.4 Current State of Quantum Technologies	
• 1.5 Challenges and Future Outlook	
Chapter 2: Mathematical Foundations	17-31
• 2.1 Linear Algebra Refresher	
• 2.2 Complex Numbers and Vector Spaces	
• 2.3 Matrices and Operators	
• 2.4 Eigenvalues and Eigenvectors	
• 2.5 Tensor Products and Hilbert Spaces	
Chapter 3: Fundamentals of Quantum Mechanics	32-45
• 3.1 Quantum States and Wavefunctions	
• 3.2 Superposition Principle	
• 3.3 Measurement Theory	
• 3.4 Entanglement	
• 3.5 Schrödinger Equation	

PART II: QUANTUM COMPUTING PRINCIPLES

Chapter 4: Qubits, Bloch Sphere, and Quantum Gates	46-58
• 4.1 Classical Bits vs Qubits	
• 4.2 Bloch Sphere Representation	
• 4.3 Single-Qubit Gates	
• 4.4 Multi-Qubit Gates	
• 4.5 Universal Gate Sets	
Chapter 5: Quantum Circuits and Noise	59-70
• 5.1 Circuit Model of Quantum Computation	
• 5.2 Quantum Circuit Design	
• 5.3 Measurement and Readout	
• 5.4 Circuit Optimization	
• 5.5 Noise and Error Sources	

Chapter 6: Quantum Algorithms	71-81
• 6.1 Introduction to Quantum Algorithms	
• 6.2 Deutsch-Jozsa Algorithm	
• 6.3 Grover's Algorithm	
• 6.4 Shor's Algorithm	
• 6.5 Variational Quantum Algorithms	

PART III: HARDWARE AND ENGINEERING SYSTEMS

Chapter 7: Quantum Hardware Technologies	82-93
• 7.1 Physical Realization of Qubits	
• 7.2 Superconducting Qubits	
• 7.3 Trapped Ion Systems	
• 7.4 Photonic Quantum Computing	
• 7.5 Scalability Challenges	
Chapter 8: Quantum Error Correction and Fault Tolerance	94-104
• 8.1 Types of Quantum Errors	
• 8.2 Error Detection Techniques	
• 8.3 Quantum Error Correction Codes	
• 8.4 Fault-Tolerant Quantum Computing	
• 8.5 Surface Codes	
Chapter 9: Engineering Applications of Quantum Computing	105-115
• 9.1 Optimization Problems	
• 9.2 Signal Processing	
• 9.3 Control Systems	
• 9.4 Material Science Simulations	
• 9.5 Quantum Sensors	

PART IV: QUANTUM COMPUTING FOR DATA SCIENCE

Chapter 10: Quantum Machine Learning	116-126
• 10.1 Introduction to QML	
• 10.2 Quantum Data Encoding	
• 10.3 Variational Circuits for ML	
• 10.4 Hybrid Quantum-Classical Models	
• 10.5 Applications in AI	
Chapter 11: Quantum Data Processing and Analytics	127-137
• 11.1 Quantum Data Structures	
• 11.2 Quantum Feature Spaces	
• 11.3 Quantum Kernel Methods	
• 11.4 Data Classification and Clustering	
• 11.5 Big Data Challenges	

Chapter 12: Quantum Optimization and Cryptography	138-155
• 12.1 Optimization in Data Science • 12.2 Quantum Approximate Optimization Algorithm (QAOA) • 12.3 Quantum Annealing • 12.4 Portfolio and Supply Chain Optimization • 12.5 Classical Cryptography vs Quantum • 12.6 Quantum Key Distribution (QKD) • 12.7 Post-Quantum Cryptography • 12.8 Security Implications	

PART V: PROGRAMMING, TOOLS, AND IMPLEMENTATION

Chapter 13: Quantum Programming Frameworks	156-164
• 13.1 Qiskit • 13.2 Cirq • 13.3 Microsoft Q# • 13.4 PennyLane • 13.5 Comparative Analysis	
Chapter 14: Practical and Cloud Quantum Computing	165-174
• 14.1 Setting Up the Environment • 14.2 Writing First Quantum Circuits • 14.3 Running on Simulators • 14.4 Accessing Real Quantum Hardware • 14.5 Debugging and Optimization • 14.6 Quantum Computing as a Service (QCaaS) • 14.7 IBM Quantum • 14.8 Google Quantum AI • 14.9 Amazon Braket • 14.10 Security Considerations	

PART VI: CASE STUDIES AND FUTURE DIRECTIONS

Chapter 15: Industry Case Studies and Future Trends	175-184
• 15.1 Finance Applications • 15.2 Healthcare and Drug Discovery • 15.3 Logistics and Supply Chain • 15.4 Smart Cities and IoT • 15.5 Aerospace and Defense • 15.6 Quantum Supremacy • 15.7 Hybrid Quantum-Classical Systems • 15.8 Ethical and Societal Impacts • 15.9 Standardization Efforts • 15.10 Roadmap to Scalable Quantum Computing	

Back Matter**185-202**

- Appendix A: Mathematical Foundations
- Appendix B: Python and Quantum Programming Examples
- Appendix C: Simulation Tools and Platforms
- Glossary
- Bibliography
- Index