QUANTUM COMPUTING TRAINER
MODEL - QUANTUMCOMP100

This Quantum Computing trainer has been designed with a view to provide practical and experimental knowledge of Quantum Computing technology.

SPECIFICATIONS

EXPERIMENTS

A. Introduction to Quantum Computing

1. Introduction
2. A Brief History of Quantum Computing
3. Main Application Areas
4. What is Quantum Computing?
5. What is a Qubit?
6. Superposition
7. Single Qubit Quantum Gates
8. Entanglement
9. Interference
10. Quantum Circuits
11. The Quantum Computing Stack
12. Applications of Quantum Computing
13. The Future of Quantum Computing

B. Introduction to Complex Numbers

14. Introduction to Complex Numbers
15. Arithmetic of Complex numbers
16. Relationship between Complex Numbers and Vectors
17. Hilbert Space and Euclidean Space Conversion
18. Euler's Formula
19. Complex Conjugate

C. Introduction to Linear Algebra

20. Scalars and Vectors
21. Vectors as Matrices
22. Find the matrix Representation of a vector
23. Matrices
24. Comparison of Matrix Types
25. Symmetric Matrix and Hermitian Matrix
26. Orthogonal Matrix and Unitary Matrix
27. Complex Conjugate
28. Matrix Multiplication to Transform a Vector
29. Tensor Product

30. Tensor Product dimension
31. Unitary and Hermitian Matrices
32. Eigenvectors and Eigenvalues
33. Unitary Matrices
34. Probability
35. Density Matrix
36. Calculate the Density Matrix
37. Purity
38. Fidelity
39. Calculate the Fidelity
40. Quantum Circuit Model

D. Python and Qiskit Setup

41. Python and Qiskit Setup on Windows
42. Python and Qiskit Setup on Linux
43. Why Qiskit?
44. Colab for researchers
45. How to code using Jupyter Notebook
46. Write a program using Qiskit
47. Bell state in Qiskit
48. Installing Dwave Ocean SDK

E. Introduction to Quantum Bits - Qubits

49. Dirac notation
50. Single Qubit
51. Multi-Qubit System

F. Introduction to Bloch Sphere

52. Introduction
53. Global Phase
54. Dimension Reduction
55. Half Angles
56. Bloch Sphere
57. Find the Bloch Vector

G. Introduction to Single Qubit Quantum Gates

58. Unitary Transformation
59. Hermitian Conjugate Operator - Common Formulas
60. How to calculate the unitary transformation matrix for a single Qubit
61. Pauli Operator
62. Theory - Initial State
63. Theory - Identity gate operates in the ground state
64. Theory - Pauli X gate operates in the ground state
65. Theory - Pauli Y gate operates in the ground state
66. Theory - Pauli Z gate operates in the ground state
67. Theory - Hadamard gate operates in the ground state
68. Theory - Rx gate operates in the ground state
69. Theory - Ry gate operates in the ground state
70. Theory - Rz gate operates in the ground state
71. Coding - Identity gate operates in the ground state
72. Coding - Pauli X gate operates in the ground state
73. Coding - Pauli Y gate operates in the ground state
74. Coding - Pauli Z gate operates in the ground state
75. Coding - Hadamard gate operates in the ground state
76. Coding - Rx gate operates in the ground state
77. Coding - Ry gate operates in the ground state
78. Coding - Rz gate operates in the ground state
79. Coding - Identity gate operates on the excited state
80. Coding - Pauli X gate operates on the excited state
81. Coding - Pauli Y gate operates in the excited state
82. Coding - Pauli Z gate operates in the excited state
83. Coding - Hadamard gate operates in the excited state
84. Coding - Rx gate operates in the excited state
85. Coding - Ry gate operates in the excited state
86. Coding - Rz gate operates in the excited state
87. Theory - Single Qubit Identities
88. Coding - Single Qubit Identities
89. Ramsey Interferometry Theory and Coding
90. Quadratic Unconstrained Binary Optimization
91. Not gate Problem
92. What is QUBO

93. QUBO for Not gate

H. Introduction to Rotation Logic Gates for Single Qubit

94. Exponential Function of Matrices
95. Generator - Pauli Matrices
96. Density Operator Matrix
97. D Rotations in Four-Dimensional Space
98. RXθ - Gate
99. RYθ - Gate
100. RZθ - Gate

I. Introduction to Multi-Qubit Logic Gates

101. Tensor Product
102. How to calculate the unitary matrix for a two-Qubit system?
103. CNOT Gate
104. SWAP Gate
105. How to calculate the unitary matrix for a three-Qubit system?
106. Toffoli CCNOT - Gate
107. Fredkin CSWAP – Gate
108. Theory - Multiple Qubits Part I
109. Theory - Multiple Qubits Part II
110. Hilbert Space Dimension
111. Theory - Two Qubits Quantum Gates
112. Coding - Two Qubits Quantum Gates
113. Two Qubits Quantum Gates
114. Qubits Gates Calculation
115. Theory - Bell States
116. Coding - Bell States
117. Coding - Reduced Density Matrix
118. Theory - Toffoli Gate
119. Toffoli gate
120. Coding - Toffoli Gate

J. Introduction to Quantum Measurement

121. Measurement and Collapse
122. The Hermitian adjoint operator and common formulas
123. Normal Matrix
124. Completeness Equation
125. Projection Operator
126. Projective Measurements
127. Measurement of a Single Qubit
128. Measurement of a Two-Qubit System

K. Introduction to Quantum Circuits

129. Introduction to Quantum Circuits
130. X Gate, Y Gate, Z Gate, H Gate
131. RXθ - Gate, RYθ - Gate, RZθ - Gate
132. CNOT Gate, SWAP Gate, Toffoli Gate
133. R phi Gate
134. S and T Gates
135. U and I Gates
136. Quantum Bit String Comparator (QBSC)
137. Midpoint Quantum Comparator (MQC)
138. Quantum Half-Adder, Full-Adder
139. Quantum Half-Substractor, Full-Substractor
140. Quantum Multiplexer, Demultiplexer
141. Quantum Adder Circuits
142. Quantum Multiplier-Accumulator
143. Quantum BCD Priority Encoder, Decoder
144. Quantum Latches, Counters
145. Quantum Barrel Shifter
146. Quantum Increment/Decrement
147. Quantum RAM
148. Quantum ALU
149. Quantum Fourier Transform

L. Quantum Algorithms

1. Hadamard Test, SWAP Test

150. Quantum entanglement
151. Hadamard Test - Real part
152. Hadamard Test – Imaginary part
153. SWAP Test

2. Amplitude Amplification

154. D Geometric Transformations
155. Transformation in Arbitrary Dimensions
156. Introduction to Amplitude Amplification
157. Amplitude Amplification Operator

3. Quantum Fourier Transformation

158. Fourier series & Fourier transform
159. Fourier Transform, DFT, IDFT
160. Quantum Fourier Transform
161. Theory - QFT
162. Theory - QFT circuits
163. Coding - QFT

4. Quantum Phase Estimation

164. Introduction
165. Quantum Circuit
166. Quantum Phase Estimation
167. Coding

5. Quantum Arithmetic Operations

168. Logic Gates
169. One-bit Adder
170. Multi-bit Adder
171. Quantum Subtractor, Multiplier, Divider

6. HHL Algorithm

172. Overview of HHL Quantum Algorithm
173. HHL Algorithm Quantum Circuit

7. Deutch Jozsa Oracle Algorithms

174. Theory - Deutch Jozsa Algorithm
175. Coding - Deutch Jozsa Algorithm
176. Theory - Bernstein Vazirani Algorithm
177. Coding - Bernstein Vazirani Algorithm
178. Theory - Simons Algorithm
179. Git Install Simons Oracle
180. Coding - Simons Algorithm
181. Deutsch–Jozsa Problem
182. Oracle - Quantum Circuit
183. Oracle - Simplification of Quantum Circuits
184. Deutsch Algorithm
185. Deutsch-Jozsa Algorithm

8. Grover Algorithm

186. Reflection and Mirror Transformation
187. Grover‘s Search Algorithm
188. Grover Algorithm - Two Qubits
189. Grover Algorithm - N Qubits
190. Theory - Grover's Algorithm
191. Theory - Grover's Algorithm Example
192. Theory - Householder Reflection and Grover's Diffusion Operators
193. Coding - Grover's Algorithm with n Qubits

9. Shor's Algorithms

194. Theory - Shor's Algorithm
195. Shor's Algorithm Example Part I
196. Coding - fx - calculation using Python
197. Theory - Shor's Algorithm Example Part II
198. Coding - QFT for Shor's Algorithm
199. Theory - Shor's Algorithm Example Part III
200. Coding - Theory - Shor's Algorithm from scratch

M. Quantum Computing in Python using Qiskit - Qiskit's Tools

201. Coding - Beautiful Circuits
202. Coding - Beautiful Results
203. Coding -Arbitrary State Initialization
204. Coding -Arbitrary Gate Initialization
205. Coding -Inverse and Transform Circuit to Gate
206. Coding -Depth and Width
207. Coding -Obtain Information about Backend Part I
208. Coding -Use real Quantum Computers
209. Big O Notation

N. Quantum Communication Protocols

210. Theory - Quantum Teleportation
211. Coding - Quantum Teleportation
212. Theory - SuperDense Coding
213. Coding - SuperDense Coding
214. Theory - BB Protocol
215. Coding - BB Protocol
216. Quantum teleportation in the IBM cloud

O. Introduction to Microsoft Q#

217. Setting up everything
218. Basic Microsoft Q# operations part 1
219. Basic Microsoft Q# operations part 2
220. Basic Microsoft Q# operations part 3
221. Basic Microsoft Q# operations part 4
222. IBM Quantum Experience 1
223. IBM Quantum Experience 2

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