

COMPANION GUIDE

Introduction

This companion guide is designed to support the audiobook version of *Demystifying Qubits*. Quantum computing can be deeply visual and mathematical. This guide presents the core visuals and symbolic notations to help you follow along, deepen your understanding, and explore further at your own pace.

Bra-Ket Notation

Quantum states are expressed using Dirac notation:

- **Ket:** $|\psi\rangle$ represents a quantum state vector.
- **Bra:** $\langle\psi|$ is its conjugate transpose.

Together, they form expressions like:

- **Inner product:** $\langle\phi|\psi\rangle$
- **Outer product:** $|\psi\rangle\langle\phi|$

These tools allow us to describe superposition, probabilities, and measurements mathematically.

Quantum Gates

Pauli-X (NOT) Gate

The quantum NOT gate flips a qubit:

$$X = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$$

This gate transforms $|0\rangle$ to $|1\rangle$ and vice versa.

Hadamard Gate

Creates superposition:

$$H = \frac{1}{\sqrt{2}} \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$$

It turns $|0\rangle$ into an equal superposition of $|0\rangle$ and $|1\rangle$.

CNOT Gate (Controlled-NOT)

A 2-qubit gate:

$$\text{CNOT} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

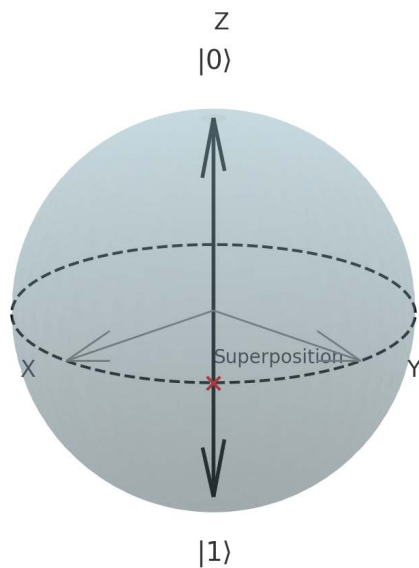
It flips the second qubit if the first is $|1\rangle$.

The Bloch Sphere

The Bloch Sphere is a 3D model of a qubit's state:

- **North pole:** $|0\rangle$
- **South pole:** $|1\rangle$
- **Equator:** superpositions with varying phase

This sphere visualizes rotation, phase, and measurement.



Probability Amplitudes

Probability amplitudes are complex numbers whose squared magnitude gives measurement probability. They can interfere constructively or destructively, similar to waves.

Additional Learning Resources

- **IBM Quantum Experience:** <https://quantum-computing.ibm.com/>
- **Quirk Quantum Sim-ulator:** <https://algassert.com/quirk>
- **Qiskit Textbook:** <https://qiskit.org/textbook/>