Classical computing versus quantum computing

Start with a familiar bit, then see what changes when information becomes quantum.

10 min read Dr. Charith Jayasekara

By the end, you'll be able to

- Distinguish a classical bit from a pure qubit.
- Explain why quantum computing is not a faster replacement for every program.
- Identify preparation, transformation and measurement in a simple workflow.

A classical bit has one of two values: **0 or 1**. A pure qubit is described by two complex amplitudes. Those amplitudes let us predict measurement outcomes and, through their relative phase, how later operations will interfere.

What changes?

Write a qubit as

$$|\psi\rangle = \alpha|0\rangle + \beta|1\rangle, \qquad |\alpha|^2 + |\beta|^2 = 1.$$

You do not need to know complex numbers yet. For now, read this as: "a state is built from two amplitudes, and the probabilities must add to one." Measuring in the computational, or Z, basis gives **one bit**: 0 with probability $|\alpha|^2$, or 1 with probability $|\beta|^2$.

A qubit does not give you two independently readable classical values. The state is richer than the outcome of one measurement.

A first experiment

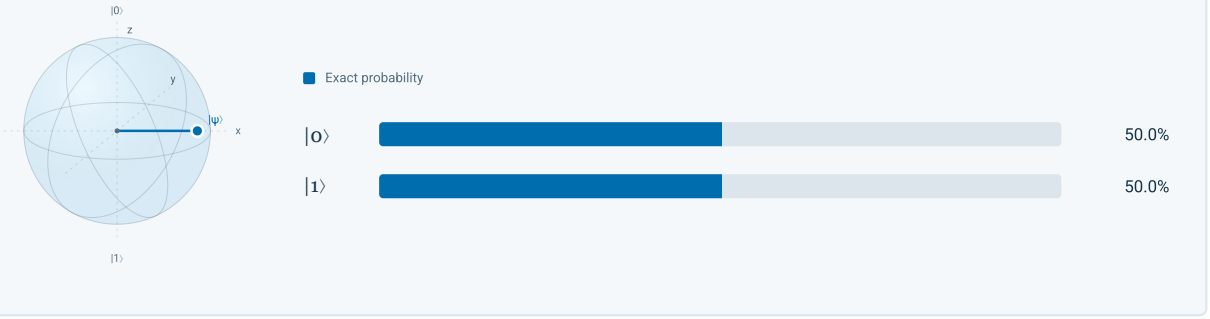
The sphere below represents a single pure qubit. Its north pole is $|0\rangle$ and south pole is $|1\rangle$. Start at the north pole, apply H, then run repeated measurements. Every shot prepares the same state again.

L01 · INTERACTIVE LAB

Runs on your device

Qubit explorer

A pure qubit is a normalised pair of complex amplitudes. The sphere shows the state; the bars show measurement probabilities in the Z basis.



MODEL · Ideal pure-state vector, complex double precision ORDER · q0 is the leftmost bit

Prediction: Move the state to the equator. What will happen to the Z-basis probabilities when you change only the phase? Challenge: Create a state with a 75% probability of measuring 1. Can you find two different phases with the same probabilities? Open the live experiment studio.

A different workflow

1. **Prepare** the input state.
2. **Transform** it using gates.
3. **Measure** to obtain classical outcomes.
4. **Analyse** repeated outcomes and compare them with a prediction.

Classical computers still handle the surrounding application: data, user interfaces, networking and analysis. Quantum methods may help with particular structured problems. A large search space by itself does not prove that a quantum approach will be practically faster.

PAUSE & THINK

What do you get from one Z-basis measurement of a qubit?

- [ ] Both amplitudes, read exactly
- [ ] One classical outcome: 0 or 1
- [ ] Every possible solution to a problem

Connect it to the source

This lesson develops sections 2–4 of the author's original introduction. Continue to quantum information or take the gentle route to qubits.

Reference: IBM Quantum — Basics of quantum information.