



# Quantum Computing Basics



Here is where your presentation begins

# Dirac Notation

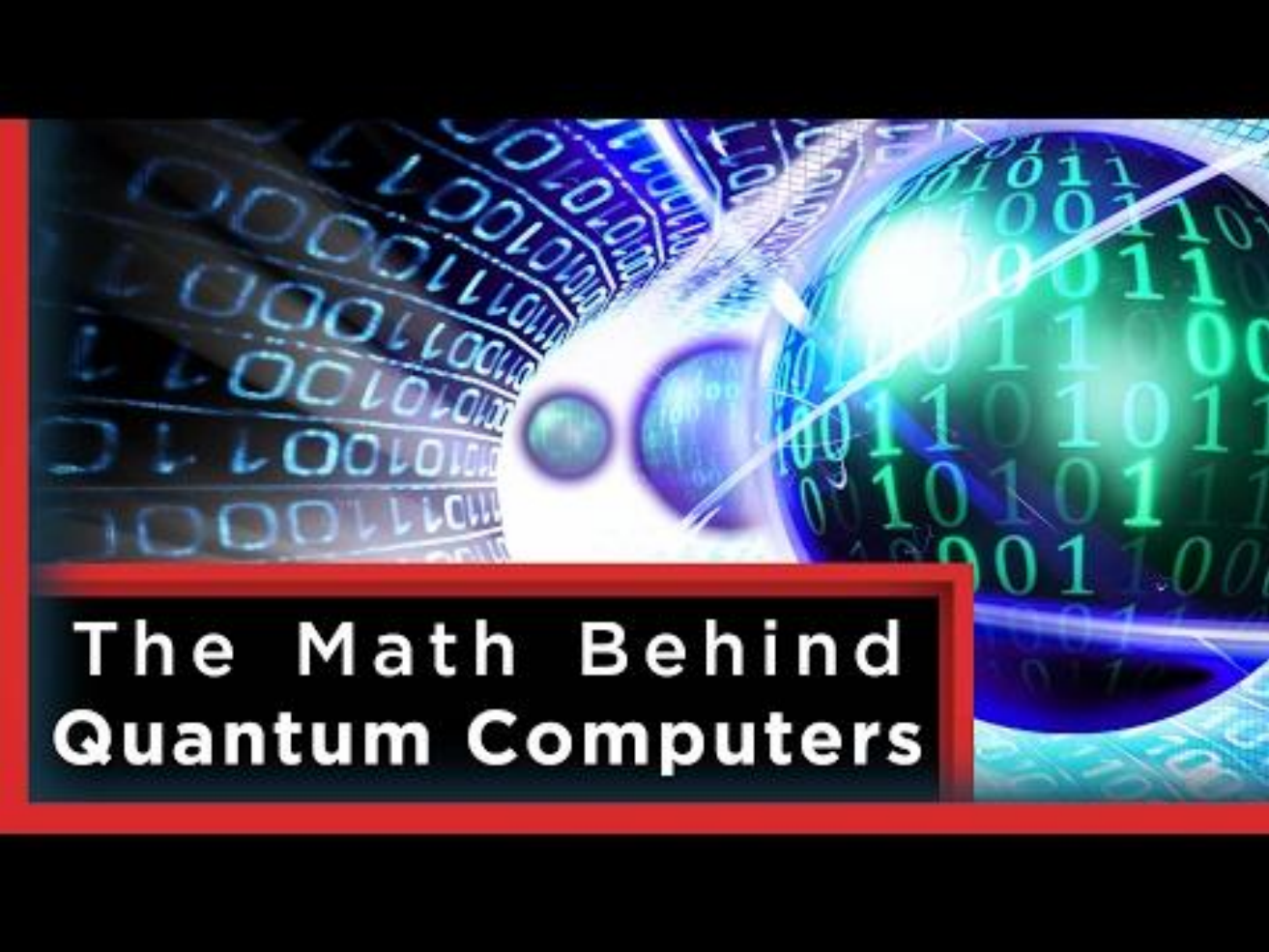
$$|v\rangle = \begin{pmatrix} v_1 \\ v_2 \\ \vdots \\ v_N \end{pmatrix}$$

$$|10\rangle = \begin{bmatrix} 0 \\ 0 \\ 1 \\ 0 \end{bmatrix}, \text{ and } |11\rangle = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \end{bmatrix}.$$

$$\text{length} \left( \begin{bmatrix} a \\ b \\ c \\ d \end{bmatrix} \right) = \sqrt{a^2 + b^2 + c^2 + d^2}$$

↙ Bra                      Ket ↘

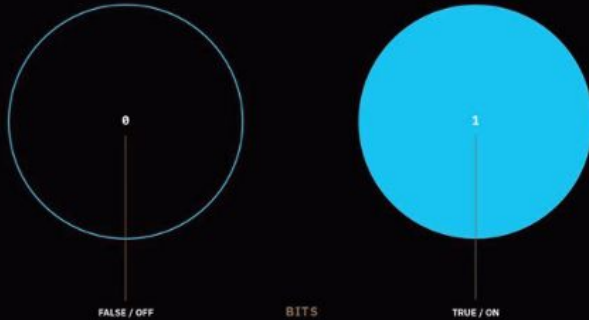
$$\langle a| = [a_1, a_2, a_3, a_4] \quad |a\rangle = \begin{bmatrix} a_1 \\ a_2 \\ a_3 \\ a_4 \end{bmatrix}$$

The background of the slide is a vibrant, abstract digital composition. It features a large, glowing green sphere on the right side, which is covered in binary code (0s and 1s). To its left, there are several smaller, glowing blue and purple spheres. The background is filled with streams of binary code in various colors (blue, green, yellow) and orientations, creating a sense of dynamic movement and digital data. The overall aesthetic is futuristic and high-tech.

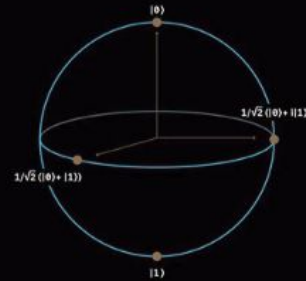
# The Math Behind Quantum Computers

# Why is quantum different?

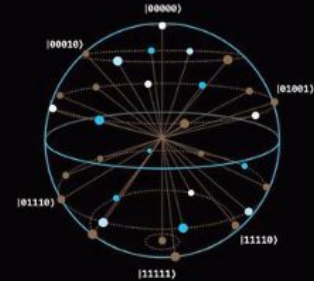
## 1. Superposition



Classical states



BLOCH SPHERE (1 QUBIT)



QSPHERE (5 QUBITS)

N qubits  
 $2^N$  paths

Quantum states

$$|0\rangle \otimes |1\rangle = \begin{pmatrix} 1 \\ 0 \end{pmatrix} \otimes \begin{pmatrix} 0 \\ 1 \end{pmatrix} = \begin{pmatrix} 1 \cdot \begin{pmatrix} 0 \\ 1 \end{pmatrix} \\ 0 \cdot \begin{pmatrix} 0 \\ 1 \end{pmatrix} \end{pmatrix} = \begin{pmatrix} 1 \cdot 0 \\ 1 \cdot 1 \\ 0 \cdot 0 \\ 0 \cdot 1 \end{pmatrix} = \begin{pmatrix} 0 \\ 1 \\ 0 \\ 0 \end{pmatrix}$$

$$\begin{pmatrix} 0 \\ 1 \end{pmatrix} \otimes \begin{pmatrix} 0 \\ 1 \end{pmatrix} \otimes \begin{pmatrix} 1 \\ 0 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 1 \\ 0 \end{pmatrix}$$

$$H \otimes I = \frac{1}{\sqrt{2}} \begin{pmatrix} 1 & 1 \\ 1 & -1 \end{pmatrix} \otimes \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} = \frac{1}{\sqrt{2}} \begin{pmatrix} 1 \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} & 1 \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \\ 1 \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} & -1 \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \end{pmatrix} = \frac{1}{\sqrt{2}} \begin{pmatrix} 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 \\ 1 & 0 & -1 & 0 \\ 0 & 1 & 0 & -1 \end{pmatrix}$$

# Takeaways

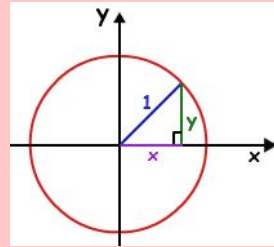
Tensors - Combining bits together using

Kets - Dirac Notation for a vector

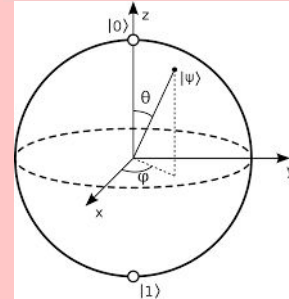
For vectors/kets -  $a^2 + b^2 + c^2 + d^2 = 1$

There can be complex numbers

$$X \otimes Y$$



Ket  
↓  
 $|a\rangle = \begin{bmatrix} a_1 \\ a_2 \\ a_3 \\ a_4 \end{bmatrix}$



# Supplementary Videos

Quantum Computing for Computer Scientists -

[https://www.youtube.com/watch?v=F\\_Riqjdh2oM&t=3039s](https://www.youtube.com/watch?v=F_Riqjdh2oM&t=3039s)

Shor's Algorithm -

<https://www.youtube.com/watch?v=lvTqbM5Dq4Q&t=734s>