# Google's Sycamore Machine and Quantum Computing

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***Source**: The Hindu*

**Manifest pedagogy:** Quantum Computing is the next big thing and the first breakthrough has been applauded unequivocally. Such breakthroughs are the important areas for Prelims. Quantum computing and its relative analysis with normal computing and supercomputing is fodder for Mains.

**In news:** Google has claimed "quantum supremacy" over the most powerful supercomputers in the world.

**Placing it in syllabus:** Recent developments in S&T

**Dimensions:**

- What is quantum computing?
- What is Sycamore and Google's claim?
- Way ahead in quantum computing

**Content:**

**What is quantum computing?**

A quantum computer is a machine that performs calculations **using the laws of quantum physics** to solve problems that would be extremely difficult, if not impossible, for **classical, semiconductor-based computers** that behave according to the **laws of classical physics.** So a classical computer computes using bits and bits can be either 1 or 0.

**Quantum supremacy** is a benchmark that was set in 2012 by a physicist named John Preskill at the California Institute of Technology, Caltech. It **means a quantum computer can do something that no ordinary classical computer can match.**

A **quantum computer** doesn’t use bits, but **uses quantum bits or qubits.** And these qubits are made out of quantum material and **a qubit** which can **exist as both 1 and 0 simultaneously**. This bizarre consequence of quantum mechanics is called a **superposition state** and is the **key to the quantum computer**‘s advantage over classical computers.

The advantage is that there are **many different possible states** and when a quantum computer is doing its calculation, **each of those states has a probability assigned to it.** A regular computer (classical computer) can only try one possible pathway at a time to get to an answer. But a quantum computer can get to the right answer more efficiently.

**What is Sycamore and Google’s claim?**

Using the company’s **state-of-the-art quantum computer, called Sycamore** (developed by a team led by John Martinis), **Google** has claimed “quantum supremacy” over the most powerful supercomputers in the world by solving a problem considered virtually impossible for normal machines.

The **world’s most powerful classical computer** is called **Summit owned by IBM** and it is as big as two basketball courts whereas Google’s quantum computer probably fits in a room.

Sycamore was given a very specific problem to solve, called a **random circuit sampling problem** ( that is, quantum equivalent of generating a very long list of random numbers and checking their values a million times over).

E.g. a pair of bits can store just one of four possible combinations of states (00, 01, 10 or 11) at any given time. A **pair of qubits can store all four combinations simultaneously**, as each qubit represents both values (0 and 1) at the same time. Google’s new computer with 53 qubits can store 253 values, or more than 10 quadrillion combinations.

Another property of quantum mechanics applied here is

**entangled states**. Particles that have interacted at some point in time can become entangled (Albert Einstein). By measuring the state of one particle allows us to simultaneously know the state of the other, regardless of the distance between the particles. **If the qubits of a quantum computer are entangled, they can all be measured simultaneously.**

Google's quantum computer consists of microscopic circuits of **superconducting metal that entangle 53 qubits** in a complex superposition state. Taking advantage of the quantum entanglement and superposition, Martinis' lab produced this distribution pattern using the Sycamore chip in **200 seconds.**

According to Google, the same calculation would take even the most powerful supercomputers approximately 10,000 years to finish. However, IBM, which has built its own 53-qubit processor estimated that it could simulate Sycamore in a mere 2.5 days, a millionfold improvement over Google's claim of 10,000 years.

**Disadvantages:**

- Whereas classical computers can stack millions of operating bits in their processors, quantum computers struggle to scale the number of qubits they can operate with.
- Entangled qubits become untangled after short periods and are susceptible to noise and errors.
- Qubits will always prove too fragile to control.

**Way ahead in quantum computing:**

- A working quantum computer would have applications from **pharmaceutical drug discovery and financial modeling to breaking the internet** by undoing a common form of encryption called RSA encryption.
- Trusted random bits generated by Google's quantum supremacy experiment, are needed for various **cryptographic applications,** such as proof-of-stake

cryptocurrencies (environmentally friendlier alternatives to Bitcoin).

- Next milestone would be the first use of **small quantum computers to simulate the quantum physics of chemicals** and materials in a way that’s actually useful to chemists and materials scientists.
- Simulating quantum mechanics could aid in the design of everything from batteries and solar cells to fertilizers and lifesaving drugs.

The first practical demonstration of **quantum error correction** (a technology that should be able to keep qubits alive for vastly longer amounts of time by encoding them across many physical qubits) will ultimately let quantum computers scale to the million or billion-qubit machines.