

National Quantum Mission (NQM)

The **National Quantum Mission (NQM)** was approved by the Indian government on **19th April 2023** with a total budget of **₹6,003.65 crore**. It will run from **2023-24 to 2030-31** and aims to make India a leader in **Quantum Technologies and Applications (QTA)** by creating a strong scientific and industrial research ecosystem.

Goals of the Mission

- 1. Quantum Computers:**
 - Develop quantum computers with **50–1,000 qubits** (units of quantum information) over the next **8 years** using technologies like superconducting and photonic platforms.
 - 2. Secure Quantum Communication:**
 - Enable **satellite-based secure quantum communication** across **2,000 km** within India.
 - Facilitate secure long-distance quantum communication with other countries.
 - Build inter-city quantum networks and **multi-node quantum key distribution systems**.
 - 3. Advanced Quantum Technologies:**
 - Develop **atomic magnetometers** (devices for measuring magnetic fields) and **atomic clocks** for ultra-precise timing, communication, and navigation.
 - Create advanced quantum materials like superconductors and unique semiconductor structures.
 - Build devices like **single-photon sources** and **entangled photon sources** for communication and sensing.
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Mission Implementation

The NQM will set up **four Thematic Hubs (T-Hubs)** in top academic and R&D institutions, focusing on:

- 1. Quantum Computing:** Research and development in quantum computer systems.
- 2. Quantum Communication:** Secure data transfer and communication systems.
- 3. Quantum Sensing & Metrology:** High-precision measuring tools and sensors.
- 4. Quantum Materials & Devices:** Development of advanced materials for quantum devices.

These hubs will promote basic and applied research and create knowledge for cutting-edge technology.

Why Is the Mission Important?

The NQM can transform key sectors such as **communication, healthcare, banking, energy, and space**. For example:

- **Drug Design:** Speed up drug discovery for new medicines.
- **Secure Banking:** Enable more secure financial transactions.
- **National Security:** Improve encryption and defense systems.

It also supports India's major initiatives like **Digital India, Make in India, Skill India, Start-up India, and Self-reliant India**.

By advancing quantum technology, India can compete globally and contribute to **sustainable development goals (SDGs)**.

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What is Quantum Computing?

Quantum computing is a new kind of computing based on **quantum mechanics**, the science of very tiny particles like atoms and electrons. Unlike regular computers (classical computers), quantum computers can solve certain problems much faster, which could revolutionize areas like medicine, cybersecurity, and space exploration.

The idea of quantum computers was first proposed in 1982 by physicist **Richard Feynman**, who wanted a computer capable of simulating quantum systems. Classical computers struggle to handle such complex calculations, leading to the creation of quantum computers.

How Do Quantum Computers Work?

1. **Classical vs. Quantum Computers:**
 - Regular computers use **bits** (0s and 1s) to store information.
 - Quantum computers use **qubits**, which can represent **0, 1, or both at the same time**. This ability is called **superposition**.
 2. **Superposition:** Imagine flipping a coin. While it spins, it's both heads and tails at the same time. Similarly, a qubit can hold multiple possibilities until it is measured.
 3. **Entanglement:** Another feature of qubits is **entanglement**, where qubits become linked. Changing one qubit instantly changes the other, no matter how far apart they are. This makes computations much faster.
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Why Are Quantum Computers Faster?

Thanks to **superposition** and **entanglement**, quantum computers can process multiple solutions at once, unlike classical computers, which solve problems step by step. For example:

- Using a quantum computer, scientists can quickly solve problems like breaking encryption codes or finding patterns in huge amounts of data.
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How Far Have We Come?

1. **Shor's Algorithm (1994)**: This method, invented by scientist Peter Shor, showed that quantum computers could factor large numbers quickly. This threatens current data encryption systems.
 2. **IBM Q System One (2019)**: IBM launched the first commercial quantum computer using circuits, designed for general-purpose tasks.
 3. **Google's Sycamore Processor (2019)**: Google achieved **quantum supremacy**, solving a problem in 200 seconds that would take the best supercomputer **10,000 years**.
 4. **Google's Willow Chip (2024)**: This chip improves **error correction**, a major challenge in quantum computing. Willow can perform tasks in minutes that would take classical computers **10 trillion trillion years**.
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Challenges in Quantum Computing

1. **Cost and Complexity**:
 - Building quantum computers is very expensive.
 - They require extreme conditions, like very low temperatures, to keep qubits stable.
 2. **Errors and Stability**:
 - Qubits are fragile and prone to errors due to interference from their surroundings (**decoherence**).
 - Millions of qubits are needed for solving real-world problems, which is still far from reality.
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India's Role in Quantum Computing

India launched the **National Quantum Mission** in 2023, with a budget of ₹6,000 crore to advance quantum technologies, including building quantum computers.

Key Takeaways

- Quantum computers rely on **superposition** and **entanglement** to process information faster than classical computers.
- Milestones include **Shor's algorithm**, IBM's **Q System One**, and Google's **Sycamore** and **Willow** chips.
- Challenges like high costs, qubit errors, and scalability remain, but countries like India are investing in their potential.