General Studies-3; Topic – Science and Technology- developments and their applications and effects in everyday life

Quantum Computing

1) Introduction

- Quantum computing is paving the way for the development of fifth generation of computers.
- It scores over existing computing methods by performing more efficient algorithms than traditional computing.

2) What is Quantum Computing?

- Quantum computing relies on quantum physics by taking advantage of certain quantum physics properties of atoms or nuclei that allow them to work together as quantum bits, or qubits, to be the computer's processor and memory.
- A quantum computer, employs the principles of quantum mechanics to store information in 'qubits' instead of the typical 'bits' of 1 and 0.
- By interacting with each other, qubits can perform certain calculations exponentially faster than conventional computers.
- For instance, to sort a billion numbers, a quantum computer would require 3.5 million fewer steps than a traditional machine.

3) Present Status

- Quantum computing has emerged as an interesting topic among students and researchers.
- Quantum computing market is expected to be worth $495.3 million by 2023.
- Just like artificial intelligence, this has created a wave of race amongst top tech giants and startups to develop the first commercially viable quantum computer.
- This will result in ground-breaking computing power which will outpace the performance of digital supercomputers.
- There has been considerable growth in research and development in the field of quantum information science.
- Raman Research Institute in Bengaluru and IISc are working on quantum computing.
- Commercial production of quantum computers is still some time away.

4) Applications

- The quantum computing technologies will have a huge impact in defence, intelligence and supremacy in the field will change the strategic balance of power.
- Besides weather predictions, quantum computing can lead to scientific breakthroughs on commercial applications such as data encryption and even new drug discovery.
- It can also lead to gains in weather predictions, financial analysis, logistical planning and also in space discovery,
- They may enable ultra-efficient logistics and supply chains, such as optimizing fleet operations for deliveries during the holiday season.
- They may make facets of artificial intelligence such as machine learning much more powerful.
- It will ultimately have huge impact on the nation and our society as a whole.

5) **Government Initiatives**
- Government set up the initiative – Quantum Information Science and Technology (QuST) to promote the future computation which will have a huge impact on India.
- The objective of QuST is to develop quantum computers and propel the development of advanced mathematical quantum techniques, algorithms and theory of quantum information systems.
- ISRO's Collaboration with Raman Research Institute (RRI) to Develop Secure Quantum Communications in Space.

6) **International Developments**
- U.S. led the way in the initial development of quantum technologies.
- China had laid the foundation for large-scale quantum networking and quantum communication.
- "QUESS" - world's first quantum satellite developed by China.
- Researchers at the National University of Singapore had built a nano-satellite with a quantum communication payload.
- The United Kingdom has outlayed $400M over five years to a new Quantum Hub Network.

7) **Concerns / Challenges**
- The biggest hurdle to developing quantum computers is the hardware issues in quantum technology.
- Lack of talent in the quantum computing industry.
- Lack of resources in quantum computing to allow undergraduate and graduate students to foray into the field.
- There are only a few institutes in India teaching quantum computing.
- In terms of R&D India lags behind other countries.
- There have been less than 100 international journal publications from India on quantum computing.
- There are fears that it will unravel the encryption that currently secures blockchains and cryptocurrencies.

8) **Way Forward**
- India will have to develop quantum science and engineering as its own discipline, at the graduate level if India wants to compete at a global stage with players like China, US and Canada.
- The industry first has to solve hardware issues in quantum technology, according to experts.
- Developing quantum computational capacity should be India's "top national priority" since sourcing these technologies from outside the country will prove to be difficult and expensive.
- This will have to be coupled with new faculty and deepening engagement with industry players.
- Increasing investment in setting up QC research centres in public-private partnerships to speed-up quantum research and development.
- Government will have to play a proactive role in generating awareness about quantum science at secondary school level.
- For India to steer ahead in the quantum computing race, the country should set up a Roadmap Group comprising of academicians, industry representatives, and end users.
- Encouraging academicians and theoretical computer scientists to work in close collaboration.
- To generate a wide interest among students, the country should set up high value fellowships to encourage doctoral and postdoctoral researchers to work in the area of quantum computing.
- More conferences and workshops should be held in India on quantum computing to generate interest.