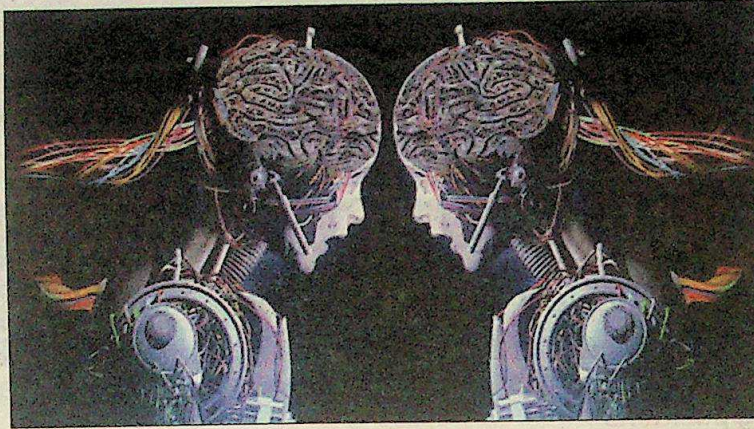


# Quantum Technology

## Future of Industry and Jobs

**Mihir Singh**

**Q**uantum technology is a rapidly emerging field that has revolutionised the way we approach computing, communication, and sensing. The implications of this technology are vast and wide-ranging, with applications in fields such as medicine, finance, and national security. Quantum technology not only has the potential to transform all industries, but it also has the capacity to generate significant employment opportunities. As the field of quantum technology continues to mature, there will be a growing demand for skilled workers in areas such as quantum computing, quantum cryptography, and quantum sensing. These new jobs will require a diverse range of skills, including expertise in physics, computer science, and engineering. Furthermore, the development of quantum technology will also lead to the creation of entirely new industries and domains, which will create additional job opportunities.



The popular domains of quantum technology in which new career opportunities are being added by the day and are expected to increase manifold in the near future are:

- ♦ Quantum Computing
- ♦ Quantum Cryptography
- ♦ Quantum Sensing
- ♦ Quantum Simulation
- ♦ Quantum Communication

### **Aptitude Required for Studying/ Pursuing Quantum Technology**

Quantum technology is built on the principles of classical mech-

anics and electromagnetism. Pursuing higher studies and a career in quantum technologies requires a strong aptitude for mathematics and physics. A solid foundation in calculus, linear algebra, and differential equations is essential, as these are the fundamental tools used to describe and manipulate quantum systems. A good under-

standing of quantum mechanics is crucial, as this is the foundation of quantum technology. Quantum technology requires a good understanding of computer science, particularly in algorithms and programming languages. You should be familiar with languages like Python, C++, and Java, as well as with data structures, algorithms, and software engineering principles. To work in quantum technology, you should be able to design, perform, and analyse experiments. This requires skills in laboratory work, data analysis, and scientific communication.

In addition to technical skills, a strong aptitude for problem-solving and critical thinking is also important. The field of quantum technology is still relatively new, and many of the

**Continued on page 52**

### **EN QUESTION OF THE WEEK**

Readers' views elicited on important issues  
Last date for entry submission: 31/05/2023

**FREE SUBSCRIPTION FOR WINNERS**

Best entry on page 55

Continued from page 1

## Quantum Technology: Future of Industry and Jobs

challenges faced by researchers and engineers require creative and innovative solutions. As such, individuals pursuing a career in quantum technology should be comfortable with taking on challenging, open-ended problems.

### Popular Industrial Applications of Quantum Technology

- ◆ **Artificial Intelligence (AI) and Machine Learning (ML):** These two domains have emerged as pivotal technologies that have disrupted industrial automation. However, traditional computer systems may struggle to handle the accuracy and speed required to implement AI-powered solutions. In this regard, quantum computing technology performs labour-intensive tasks faster than conventional computers.
- ◆ **Pharmaceutical Sector:** Drug development is a challenging area that can benefit from quantum computing's speed and cost reduction. Quantum computing technology can be employed throughout the drug development process to replace laboratory tests with quantum computer simulations, thereby providing viable quantum application. Computational chemistry can revolutionise molecular mapping through coherent superposition of qubits as either 0 or 1 can fuel molecular mapping and help the pharmaceutical sector.
- ◆ **Cybersecurity:** As the internet drives companies and organisations to gain international momentum and boost user acquisitions, cyber attack has become a significant threat. Quantum computing applications utilising machine learning algorithms and quantum cryptography can be used to counter cybersecurity threats and impose higher security norms.
- ◆ **Data Processing:** Cloud computing services aim to make automation and performance agility accessible to businesses in all sectors. Integrating quantum computing and cloud computing would be the most natural fit among all technological innovations. Custom-made quantum app development and cloud computing services can break up massive data processing into several manageable bits of data.
- ◆ **Finance and Investments:** Investors face challenges in finding ideal investment opportunities with high returns and low-risk factors. With the creation of useful quantum computing applications, businesses can carry out these calculations quickly and easily, reduce the time required, enhance the quality, and handle enormous sums of money more simply.
- ◆ **Fraud Detection:** Industries such as healthcare, banking, and marketing requires reliable solutions for deriving functional entity relationships and data patterns. Quantum computing can make data modeling more efficient and timely.
- ◆ **Weather Forecast:** Meteorology and weather forecasting is another potential application of quantum computing. Powerful quantum computing solutions that provide quick and easy processing of massive datasets may prove to be a profitable way to model weather systems.
- ◆ **Online Traffic Optimisation:** Improving organic traffic for

organisations is another use of quantum computing applications based on data extraction and pattern analysis. Companies that provide marketing and advertising services need to employ quantum computers to offer quick services with precise outcomes and a perfectly targeted audience.

- ◆ **Supply-chain Management:** This domain requires improved data analysis and reliable performance modeling to enhance logistics optimisation. Quantum computing can provide strong computational solutions for logistics optimisation, with quantum annealing technology offering powerful answers when compared to conventional computers. Universal quantum computing methods can resolve all computational issues.
- ◆ **Quantum Warfare:** Quantum technology, while not yielding fundamentally new weapons or standalone military systems, possesses the power to substantially elevate measurement capability, sensing, precision, and computation efficiency of both current and future military technology. The majority of quantum technologies are of dual use, offering an abundance of potential for military applications. The technology also has the potential of affecting the intelligence capability of defence forces. This remarkable potential for innovation and advancement in military capabilities is one that cannot be overlooked.

### Job Roles

As the field of quantum computing continues to grow, there is a significant demand for skilled professionals who can develop, program, and operate quantum computers. This demand is being driven by a range of industries, including finance, healthcare, and aerospace, who are all looking to leverage the unique capabilities of quantum computing to solve complex problems and gain a competitive edge. In addition to quantum computing, there are also growing job opportunities in other domains of quantum technology, such as quantum cryptography, quantum sensing, and quantum simulation. While these domains may not have as many job openings as quantum computing, they are still experiencing significant growth.

**Research Scientist:** Research Scientists typically hold Ph.D. degrees in physics, computer science, or a related field. They are responsible for conducting research on quantum computing, developing new algorithms, and testing the capabilities of quantum computers.

**Quantum Software Developer:** Quantum Software Developers are responsible for developing software applications and tools that can run on quantum computers. They typically have expertise in programming languages such as Python, C++, and Q#, and are familiar with quantum algorithms and quantum circuit design.

**Quantum Hardware Engineer:** Quantum Hardware Engineers design and develop the hardware components of quantum computers. They typically have expertise in areas such as superconducting circuits, ion traps, and photonics.

**Quantum Application Developer:** Quantum Application Developers are responsible for developing applications that can leverage the unique capabilities

of quantum computers. They typically have expertise in areas such as chemistry, finance, or optimisation, and are able to design algorithms that can solve complex problems in these areas.

**Quantum Information Scientist:** Quantum Information Scientists are responsible for developing and testing new quantum information protocols, such as quantum cryptography and quantum error correction. They typically have expertise in both physics and computer science, and are able to design and analyse complex quantum information protocols.

**Cryptography:** Cryptography is used to protect sensitive information, such as passwords, financial transactions, and confidential communication, from being intercepted or tampered with. The technology finds application in a variety of modern communication systems, including secure web browsing, email encryption, digital signatures, and password storage. It is also used in secure messaging, secure file storage, and secure authentication. Quantum technology has the potential to revolutionise cryptography by providing new tools and techniques for secure communication and to create new cryptographic systems that are resistant to quantum attacks.

**Quantum Cryptographer** is responsible for developing and implementing secure cryptographic protocols and algorithms. They work with quantum computers and quantum communication systems to develop new cryptographic techniques that are resistant to attacks by quantum computers.

**Cryptographic Engineer** designs and implements cryptographic algorithms and protocols for various applications, such as secure messaging, secure web browsing, digital signatures, and password storage. With the increasing demand for quantum-safe cryptographic systems, cryptographic engineers with expertise in quantum technology are in high demand.

**Information Security Analysts** are responsible for protecting an organisation's information systems from cyber attacks and data breaches. With the increasing threat of quantum attacks, information security analysts with expertise in quantum cryptography are needed to develop and implement quantum-safe security measures.

**Quantum Communication:** Satellite-based quantum communication is a rapidly growing field with great potential for both scientific advancement and commercial applications. As such, there are many lucrative career opportunities available in this field for individuals with the necessary skills and expertise.

**Quantum Information Scientist/Engineer:** One of the most important roles in satellite-based quantum communication is that of a quantum information scientist or engineer. These professionals are responsible for designing and implementing quantum communication protocols and systems, as well as developing new quantum technologies and applications. They typically have advanced degrees in physics, electrical engineering, or computer science, and may work in academia, government research labs, or private industry.

**Satellite Systems Engineer:** These professionals are responsible for designing, building, and maintaining the complex satellite systems that enable quantum communication between ground

stations and other satellites. They typically have degrees in aerospace engineering or a related field, and may work for government agencies such as NASA or private companies such as SpaceX or Boeing.

**Business and Management Professionals:** In addition to technical roles, there are also many opportunities for business professionals with expertise in satellite-based quantum communication. For example, individuals with experience in marketing, sales, or business development may work for companies that develop and sell satellite-based quantum communication systems, while those with legal or regulatory expertise may work for government agencies or private companies to ensure compliance with relevant laws and regulations.

**Quantum Sensing:** This is a rapidly growing field with significant implications for various industries. Its applications range from medical imaging to mineral exploration to navigation systems, and its potential for high-precision measurement has caught the attention of researchers, engineers, and investors alike. As the technology continues to advance, the demand for skilled professionals in the field, such as quantum engineers and quantum materials scientists, is on the rise and the professionals who fill these roles are poised to make significant contributions to the advancement of technology.

**Quantum Sensing Engineers:** The expertise of Quantum Engineers in the development of high-precision sensors, quantum signal processing algorithms, and low-noise electronic systems is critical to the success of the technology. With degrees in physics, engineering, or computer science, they possess the technical knowledge and experience in quantum mechanics, electronics, and software development necessary to excel in this role.

**Quantum Materials Scientists:** They explore the properties of materials at the quantum level to develop new materials with specific properties relevant to quantum sensing. They study physics, chemistry, and materials science, and are adept at the synthesis and characterisation of materials, and their research has far-reaching implications for the advancement of quantum sensing technology.

**Quantum Sensing Researchers:** They develop new sensing technologies that harness the power of quantum mechanics. They conduct experiments to test the feasibility of new quantum sensing approaches and develop new theoretical models to predict their behaviour. They have the necessary skills in experimental design and data analysis to contribute to the cutting-edge research in the field.

**Quantum Sensing Product Managers:** These professionals working closely with customers, engineers, and researchers to define product requirements and prioritise development efforts. Degree in engineering coupled with degree in business or a related field and experience in product management, marketing, and sales, are required to lead the charge in bringing quantum sensing technology to the forefront of various industries.

**Quantum Sensing Applications Engineers:** They play a crucial role in the integration of quantum sensing systems into various applications, such as medical

Continued on page 54

# Kaladan Multimodal Transit Transport Project

## EN EXPLAINS

Development Cooperation has been a prominent feature in India's overall bilateral engagement with Myanmar. India's involvement and engagement in Myanmar extend from the setting up of major connectivity infrastructure to significant initiatives in establishing long-term, sustainable and relevant institutions for capacity building and human-resource development in critical areas such as agricultural research, education, IT, skill development, etc.

Recognising the vital role that the transportation sector plays in the accelerated economic growth, the Government of India placed a high priority in this sector's development to meet the current and future highway transportation needs. An agreement was reached between the Governments of India and Myanmar in April 2008 to develop a multimodal trade route (means of transport consisting of sea, inland water, roads & railways and land) between the two countries and to facilitate implementation of the project.

The Kaladan Multimodal Transit Transport Project (KMTTP) is perhaps the most significant project undertaken by India in Myanmar. This project was jointly identified by India and Myanmar to create a multi-modal mode of transport for shipment of cargo from the eastern ports of India to Myanmar as well as to the North-Eastern part of India through Myanmar. This project, which connects the Sittwe Port in

Myanmar to the India-Myanmar border, will contribute to the economic development of the Northeastern States of India, by opening up the sea route for the products.

In a major step towards enhancing trade and commerce between India and Myanmar, the inaugural cargo ship was flagged off from Syama Prasad Mookerjee Port in Kolkata to the Sittwe Port in Myanmar on May 5, 2023. On May 9, 2023, Union Minister of Ports, Shipping & Waterways, Shri Sarbananda Sonowal visited the Sittwe Port in the Rakhine state of Myanmar which he jointly inaugurated with the Deputy Prime Minister & Union Minister for Transport & Communication of Myanmar, Admiral Tin Aung San, as they received the first Indian cargo ship at the port.

The Sittwe port has been built with grant assistance from the Government of India as part of this Transport Project. The route is expected to unlock tremendous economic potential for the entire Bay of Bengal peninsula, allowing a bridge between South Asia and South East Asia regions.

The project is in line with India's 'Act East Policy' which aims to promote economic cooperation, cultural ties and develop strategic relationships with countries in the Asia-Pacific region by providing enhanced connectivity to the States of North Eastern Region with other countries in our neighbourhood. The policy provides an interface between North Eastern India including the State of Arunachal

Pradesh and the Association of South East Asian Nations (ASEAN) region.

The KMTTP will serve as one of the most important corridors for freight movement between the two countries. The project includes a waterway component of 158 km on Kaladan River from Sittwe to Paletwa and a road component of 109 km from Paletwa to Zorinpui on the India-Myanmar border in Mizoram State. It also provides a strategic link to the North-East, thereby reducing pressure on the Siliguri Corridor.

KMTTP comprises four sections - from India to Sittwe Port via maritime shipping, from Sittwe to Paletwa via Kaladan river, from Paletwa to Indo-Myanmar border and from India border to NH via road.

In the absence of an alternate route, the development of this project not only serves the economic, commercial and strategic interests of India, but also contributes to the development of Myanmar, and its economic integration with India. Since the project is of political and strategic significance, it was decided to execute it through India's grant assistance to Myanmar.

### Connectivity with the Northeast India

The development of the port has various benefits for India. The route is a far more feasible route for the trade and commerce of Northeast India than the existing route via Siliguri to Kolkata, saving time and money and excelling in efficiency. The cost of

transportation of goods from Kolkata to Aizawl is envisioned to drop by more than 50 per cent in both cost and time when the cargo is sent from Kolkata to Sittwe onto Paletwa, and after that via road to Aizawl and the whole of Northeast India. The port will also provide an alternative route for India to access Southeast Asia.

**From Paletwa in Myanmar to Zorinpui in Mizoram:** The Sittwe port connects to Paletwa in Myanmar through an inland waterway and from Paletwa to Zorinpui in Mizoram through a road component.

**From Sittwe, Myanmar to Sarboom, Tripura:** Goods from Kolkata to Sittwe Port can be shipped to Teknaf Port, Bangladesh which is just 60 nautical miles off Sittwe. From Teknaf Port goods can be transported by road to Sabroom which is 300 km away. Sabroom has an integrated customs border between Bangladesh and Tripura. Sittwe port and Kaladan Project will immensely benefit Tripura by way of significant reduction in transportation time and logistics cost.

### Advantages

The proposed trade route between the two countries will serve as a major intra and inter regional trade route, economically and culturally. It will also serve as one of the most important corridors for freight movement between the two countries. The proposed transport connectivity will also help in socio economic development of the north eastern region of India by

allowing cargo to be transported from Kolkata, Haldia and other foreign ports via the ports of Sittwe/Kaletwa by coastal shipping, inland water transport and road transport modes with cheaper cost and vice versa. Once the proposed trade route is completed and put into use it will greatly boost the trade between the two neighbouring countries, viz. India and Myanmar.

Major cargo for export for Sittwe Port, i.e., exports from Myanmar include Rice, Timber, Fish and Seafood, Petroleum Products and Garments and Textiles. The major cargo for import for Sittwe Port, i.e. imports by Myanmar include construction materials such as cement, steel and bricks among others.

The port route will unlock huge commercial potential for the entire Bay of Bengal peninsula, Bangladesh, Bhutan, and Nepal by acting as a bridge with Southeast Asia. Notably, the use of marine transport will considerably bring down the environmental cost of transport with a drop in fossil fuel carbon emissions.

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Continued from page 52

## Quantum Technology: The Future of Industry and Jobs

imaging, mineral exploration, or navigation systems. Apart from being engineers, these professionals also need to have a sound understanding of IT and customer-centric mindset that are necessary to design customised solutions that meet the needs of a diverse range of customers.

### Where to Study Quantum Technology in India?

India has emerged as a significant player in the global quantum computing landscape, with several institutions offering courses and training programmes in this rapidly evolving field. Here are some top Indian Institutes for quantum computing:

- ♦ Indian Institutes of Technology (IITs), different campuses countrywide
- ♦ Raman Research Institute, Bengaluru
- ♦ International Institute of Information Technology (IIIT), Hyderabad
- ♦ Harish-Chandra Research Institute (HRI), Allahabad
- ♦ National Institute of Technology (NIT), Warangal
- ♦ Indian Institute of Science, Bengaluru

- ♦ Indian Institute of Science Education and Research, Bhopal
- ♦ Tata Institute of Fundamental Research (TIFR), Mumbai
- ♦ Calcutta University, Kolkata
- ♦ Indian Statistical Institute, Kolkata

### General Course Structure (M.Tech in Quantum Technology)

Typically, the first year of M.Tech in Quantum Technology will cover the following topics:

- ♦ Quantum Mechanics
- ♦ Quantum Computation and Information
- ♦ Quantum Optics and Photonics
- ♦ Quantum Algorithms and Complexity
- ♦ Quantum Error Correction and Fault-Tolerance
- ♦ Advanced Mathematics for Quantum Applications
- ♦ Quantum Cryptography and Information Security
- ♦ Advanced Topics in Quantum Applications

In the second year, students will have to undergo an advance course structure including a research project/thesis/

internship to finally hold a Master's degree in Quantum Technology.

- ♦ Quantum Hardware and Technology
- ♦ Quantum Materials and Devices
- ♦ Quantum Sensing and Metrology
- ♦ Quantum Communication and Networking
- ♦ Quantum Machine Learning and Artificial Intelligence
- ♦ Quantum Computing in Chemistry and Materials Science
- ♦ Quantum Computing in Biology and Life Sciences
- ♦ Research Project/Thesis

(The above course structure is indicative only and may vary from institution to institution).

### Admission Requirements

Admission requirements for quantum technology programmes may vary depending on the specific institution and programme. However, some general admission requirements may include:

- ♦ **Educational Qualifications:** Applicants are typically required to have a bachelor's degree in physics, computer science, engineering, or a related field. Some programmes may also accept applicants with a background in mathematics or other related fields.
- ♦ **GPA:** Applicants are usually required to

have a minimum GPA of 3.0 or higher on a 4.0 scale.

- ♦ **Standardised Test Scores:** Some programmes may require applicants to submit standardised test scores such as that of JEE -Mains (for B.Tech in Quantum Technology) and GATE (for M. Tech in Quantum Technology).

As we move towards a future where quantum technology plays an increasingly important role in our lives, it is crucial that we invest in education and training programmes that will equip the workforce with the skills needed to succeed in this exciting new field. There is also a need for creating an ecosystem that can assimilate the dynamics of this rapidly changing and expanding field of science and ensure that businesses and organisation are able to optimally utilise its applications. By doing so, we can ensure that the benefits of quantum technology are accessible to all, while also promoting economic growth and job creation. This is the intent behind the recently launched National Quantum Mission.

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