Workshop on "Hands-On Training on Quantum Technologies & Applications Using Qiskit"

3rd–4th April 2025, Jointly Organized by SeNSE, IIT Delhi and QMD Foundation, IIT Delhi

Introduction

The **Quantum Materials and Devices (QMD) Foundation**, as part of its mission to advance quantum education in India, sponsored a two-day intensive workshop titled *"Hands-on Training on Quantum Technologies & Applications using Qiskit"* at **IIT Delhi**. Organized by **SeNSE, IIT Delhi**, the event brought together **students, researchers, and faculty** from across the country to explore practical applications of quantum computing.

The workshop aligned with the **National Quantum Mission** and the QMD Hub's objectives to:

- Bridge the gap between **quantum theory and real-world implementation**.
- Foster collaboration between **academia and industry leaders** like IBM and NPL.
- Equip participants with **job-ready skills** in quantum programming and algorithm design.

Event Overview

Inaugural Ceremony

The workshop began with a welcome address by **Prof. Jasleen Lugani (Convener)**, who highlighted the growing demand for quantum-skilled professionals. In her

opening remarks, Dr. M.H. Rahaman (Director, DIA-CoE, IIT Delhi emphasized the role of CoEs (Centres of Excellence) in nurturing quantum research.

Prof. Rajendra Singh (Associate Dean, R&D and Director, QMD Foundation at IIT Delhi) recently shared the vision and strategic roadmap of the Quantum Materials and Devices (QMD) Hub as part of India's growing quantum ecosystem. In his address, Prof. Singh elaborated on the role of the QMD Hub in advancing the objectives of the National Quantum Mission (NQM), emphasizing the urgent national need for innovation and self-reliance in quantum technologies. He highlighted the government's substantial investment in the NQM, aimed at positioning India as a global leader in quantum research and technology. The mission includes several Technology Hubs (T-Hubs), each with a dedicated focus area and anchored by premier institutions across the country. Specifically, IIT Delhi hosts the T-Hub on Quantum Materials and Devices, which will drive research and development in next-generation quantum materials, devices, and scalable technologies. Prof. Singh outlined the other three pillars of the NQM's research thrust: Quantum Metrology, Quantum Computing, and Quantum Communications. These domains are expected to deliver transformative advances in secure communications, ultra-precise measurements, and computational capabilities far beyond classical systems.

The QMD Hub at IIT Delhi will not only focus on cutting-edge R&D but will also foster a vibrant ecosystem for entrepreneurship, start-up incubation, educational outreach, and international collaborations. It aims to serve as a nucleus for quantum workforce development, bridging the gap between academic research and industry applications, and cultivating a new generation of scientists, engineers, and innovators in the field of quantum materials and devices.

Prof. Singh emphasized that, with such significant government support, the expectation is high for breakthrough outcomes that can establish India's leadership in quantum technologies on the global stage.

In his keynote address, Prof. Achanta Venugopal, Director, NPL focused on India's quantum infrastructure challenges and NPL's work in quantum standards and metrology. He also stressed the need for homegrown quantum hardware to reduce reliance on imports.

Technical Sessions

On Day 1 technical session on Foundations of Quantum Computing included following sessions with respective speakers in the relevant areas**.**

Session 1: Superconducting Quantum Technology

Speaker: Dr. Richa Goel (QMD Hub)

- Covered **qubit types (transmon, fluxonium)**, coherence times, and error mitigation.
- Demonstrated how **superconducting circuits** outperform classical counterparts in optimization tasks.

Session 2: Hands-on Qiskit Lab

Instructor: Mr. Sidhartha Golecha (IBM Research)

- Participants implemented:
  - **Bell-state circuits** (entanglement generation).
  - **Grover's algorithm** for unstructured search.
- Used **IBM Quantum Lab** for real-device executions.

Panel Discussion: "Quantum Readiness in India"

- Topics: Workforce gaps, startup opportunities, and policy support.
- Key takeaway: **"India must prioritize quantum education at the undergraduate level."**

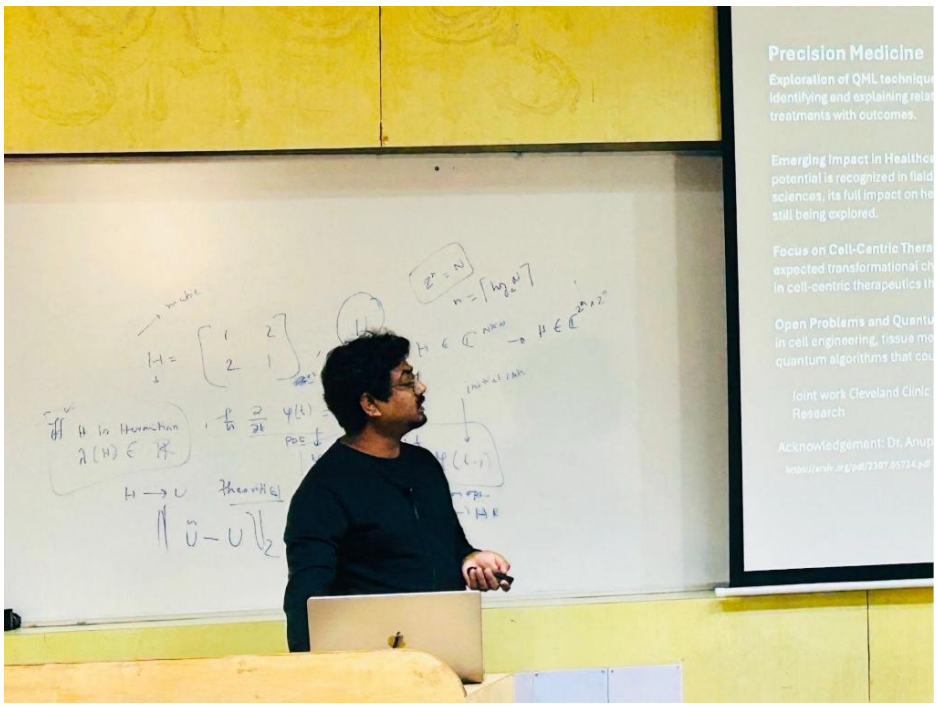
On Day 2 technical session on Advanced Applications

Session 3: Quantum Simulation & Optimization

- **Dr. Richa Goel & Dr. Mostafizur Rahaman (IBM Research)**
  - **Max-cut problems**: Used Qiskit's **QAOA (Quantum Approximate Optimization Algorithm)**.
  - **Quantum chemistry**

Session 4: Quantum Machine Learning

- **Instructors: Mr. Dhiraj Madan & Mr. Siddharth Golecha (IBM)**
  - Built **hybrid quantum-classical models**



Participant Feedback & Outcomes

Skill Development

- **Pre-/Post-Workshop Survey Results**:
  - 92% reported **improved confidence** in quantum programming.
  - 85% could **design and execute basic quantum circuits** independently.

Notable Participant Quotes

- *"The hands-on labs made abstract concepts like superposition tangible."*
  — MSc Physics student, IIT Delhi.
- *"Interacting with IBM researchers clarified industry expectations."*
  — PhD candidate, IIT Delhi.

Career Impact

- **Participants** can be shortlisted for **IBM Quantum internships**.
- **QMD Hub** may announce **funding opportunities** for quantum projects.

Broader Impact & Future Initiatives

Aligning with National Goals

- The workshop directly supported the **National Quantum Mission's** mandate to train **50,000 quantum professionals by 2030**.

Conclusion

This workshop successfully delivered **practical quantum skills** while fostering a collaborative ecosystem. The **QMD Hub** reaffirms its commitment to making India a global quantum leader through such initiatives.

Acknowledgements
We thank **Prof. Rajendra Singh (QMD Hub Director)**, **Dr. Richa Goel**, **IBM Research**, and **Prof. Jasleen Lugani**, **SeNSE, IIT Delhi** for their support.