# Quantum Computing: A Deep Dive (Concepts to Applications)
## Duration: 2 weeks (02 July, 2025 to 15 July, 2025)

## Course Content

## WEEK-1

### Day 1:Fundamentals of Quantum Computing
- Introduction to Quantum Computing
- Qubits, superposition, entanglement, and quantum gates
- Basic quantum gates: Pauli-X, Pauli-Y, Pauli-Z, Hadamard, and CNOT gates
- Quantum circuits and measurement basics
- Hands-on: Setting up quantum computing environments

### Day 2: Python Programming for Quantum Computing
- Python essentials: Functions, loops, classes, and libraries.
- Overview of NumPy, SciPy, and Matplotlib for scientific computing.
- Hands-on: Implementing basic quantum-like algorithms (random walks, Markov processes) in Python.
- Introduction to Jupyter notebooks for quantum experimentation.

### Day 3: Quantum SDKs
- Introduction to Qiskit: Overview and installation.
- Building quantum circuits using Qiskit.
- Hands-on: Running basic quantum circuits and measuring results.
- Simulating quantum operations and visualizing results.

### Day 4: Quantum Data Representations
- Quantum state representations of data: Quantum feature maps, density matrices, and tensors
- Encoding classical data into quantum states
- Hands-on: Representing classical data in quantum states using Qiskit and PennyLane

### Day 5: Quantum Circuits and Algorithms
- Concept of quantum circuits.
- Creating and manipulating quantum states using quantum gates.
- Basic Quantum Algorithms
- Implementations of Grover's Search Algorithm

## WEEK-2

### Day 6:Quantum Machine Learning Applications
- Key QML Concepts and Types
- Hybrid quantum-classical approaches

- Quantum-enhanced kernel methods for ML

- o Applications in SVMs and clustering tasks
- o Building a quantum-enhanced SVM

### Day 7: Advanced Quantum Optimization Algorithms
- o Quantum Approximate Optimization Algorithm (QAOA)
- o Variational Quantum Eigensolver (VQE)
- o Hands-on: Implement QAOA for optimization problems

### Day 8:Quantum in Healthcare
- o Quantum computing for Healthcare Applications
- o Leveraging Quantum Advantage in early disease diagnosing
- o Hands-on: Simulate a healthcare-related classification problem using quantum algorithms

### Day 9: Quantum Networking and Communication
- o Quantum communication: principles and technologies (QKD)
- o Overview of the Quantum Internet and its potential
- o Hands-on: Simulate quantum-secure communication (Quantum Teleportation & Super Dense Coding)

### Day 10: Big Data&Quantum Data Analytics
- o Quantum Principal Component Analysis (QPCA): Efficiently process high-dimensional data.
- o Improve speed and scalability of clustering algorithms.
- o Applications in predictive analytics and decision-making systems.

**Course Summary**

**The course covers quantum computing fundamentals, quantum circuits, algorithms, and quantum SDKs in the first week, followed by quantum machine learning, optimization, healthcare applications, quantum networking, and big data analytics in the second week. Participants will gain hands-on experience with Qiskit, PennyLane, and quantum-enhanced algorithms, preparing them for real-world quantum applications through theory, practical exercises, and assessments.**