INFOSOFT IT SOLUTIONS

Training | Projects | Placements

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IBM QUANTUM COMPUTING TRAINING

1: **Introduction to Quantum Computing**

- **Overview of Quantum Computing**
  - History and background
  - Classical vs. quantum computing
- **Basic Concepts of Quantum Mechanics**
  - Quantum states and qubits
  - Superposition and entanglement
- **Introduction to IBM Quantum Experience**
  - Overview of IBM Quantum and Qiskit
  - Setting up IBM Quantum account

2: **Qubits and Quantum Gates**

- **Qubit Representation**
  - Bloch sphere representation
  - Quantum state notation
- **Quantum Gates and Circuits**
  - Single-qubit gates: X, Y, Z, H, S, T
  - Multi-qubit gates: CNOT, Toffoli, Swap
  - Building quantum circuits in Qiskit

3: **Quantum Measurement and Noise**

- **Measurement in Quantum Computing**
  - Measurement bases and probabilities
  - Collapsing quantum states

- **Quantum Noise and Error**
  - Types of quantum errors
  - Error correction basics
  - Noise models in Qiskit

4: **Quantum Algorithms I**

- **Quantum Algorithm Basics**
  - Introduction to quantum algorithms
  - Quantum parallelism and interference
- **Simple Quantum Algorithms**
  - Deutsch-Jozsa algorithm
  - Bernstein-Vazirani algorithm
  - Implementing algorithms in Qiskit

5: **Quantum Algorithms II**

- **Grover's Algorithm**
  - Problem statement and solution
  - Circuit implementation
- **Shor's Algorithm**
  - Quantum Fourier Transform
  - Integer factorization
  - Implementation challenges

6: **Quantum Computation Models**

- **Circuit Model of Quantum Computation**
  - Gate-based quantum computing
- **Alternative Models**
  - Measurement-based quantum computing
  - Adiabatic quantum computing

7: Advanced Quantum Algorithms

- **Quantum Phase Estimation**
  - Applications and importance
  - Implementation details
- **Quantum Simulation**
  - Simulating quantum systems
  - Applications in chemistry and materials science

8: **Quantum Programming with Qiskit**

- **Qiskit Basics**
  - Qiskit framework and components
  - Writing and running quantum programs
- **Qiskit Terra and Aer**
  - Circuit construction and simulation
  - Noise simulation and analysis

9: **Quantum Information Theory**

- **Quantum Entropy and Information**
  - Shannon entropy vs. quantum entropy
  - Quantum mutual information
- **Quantum Cryptography**
  - Quantum key distribution (QKD)
  - Protocols like BB84 and E91

10: **Practical Quantum Computing**

- **Quantum Hardware**
  - Superconducting qubits
  - Trapped ions and other technologies
- **IBM Quantum Systems**
  - Overview of IBM Q systems
  - Accessing and using IBM Quantum devices

11: **Research and Applications**

- **Current Research in Quantum Computing**
  - State of the art and future directions
- **Industry Applications**
  - Finance, cryptography, optimization

ADVANCE TOPICS ;-

1: Advanced Quantum Mechanics for Computing

- **In-Depth Quantum Mechanics**
  - Review of basic quantum mechanics
  - Advanced topics: tensor products, Bell states
- **Advanced Qubit Operations**
  - Multi-qubit systems and entanglement
  - Density matrices and mixed states

2: Quantum Gates and Circuits

- **Advanced Quantum Gates**
  - Multi-controlled gates
  - Universal quantum gates and gate decomposition
- **Circuit Optimization**
  - Gate efficiency and optimization techniques
  - Circuit depth and error mitigation

3: Quantum Error Correction

- **Error Sources in Quantum Computing**
  - Decoherence and noise models
- **Quantum Error Correcting Codes**
  - Shor code, Steane code, and surface codes
  - Implementing error correction in Qiskit

4: Quantum Algorithms III

- **Advanced Grover's Algorithm**
  - Applications and modifications
  - Amplitude amplification
- **Advanced Shor's Algorithm**
  - Detailed steps and implementation
  - Quantum modular exponentiation

5: Quantum Complexity Theory

- **Quantum Complexity Classes**
  - BQP, QMA, and other complexity classes
- **Quantum Speedup**
  - Criteria and examples of quantum advantage

6: Quantum Information Theory and Cryptography

- **Advanced Quantum Information Theory**
  - Entanglement measures and distillation
  - Quantum channel capacities
- **Advanced Quantum Cryptography**
  - Quantum key distribution beyond BB84
  - Quantum teleportation and superdense coding

7: Quantum Machine Learning

- **Introduction to Quantum Machine Learning**
  - Quantum data and algorithms
  - Variational quantum algorithms for machine learning
- **Implementation in Qiskit**
  - Qiskit Machine Learning module
  - Practical examples and case studies

8: Quantum Simulation and Chemistry

- **Quantum Simulation**
  - Simulating quantum systems on quantum computers
  - Applications in condensed matter physics
- **Quantum Chemistry**
  - Quantum algorithms for chemistry
  - Implementing VQE and QAOA for molecular problems
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9: Topological Quantum Computing

- **Introduction to Topological Quantum Computing**
  - Anyons and topological qubits
- **Implementing Topological Codes**
  - Surface codes and fault-tolerance

10: Quantum Hardware and Architecture

- **Quantum Hardware Advances**
  - Superconducting qubits and their challenges
  - Other qubit technologies: trapped ions, topological qubits
- **Quantum Computing Architectures**
  - Networked quantum computing
  - Scalable quantum computing architectures

11: Current Research and Developments

- **Frontiers of Quantum Computing Research**
  - Recent breakthroughs and ongoing research areas
- **Quantum Computing Ecosystem**
  - Industry players and research institutions
  - Collaborative research and open science