Training Course on Quantum Machine Learning Fundamentals

Professional Development Training Course Outline

Category	Data Science	**Duration**	10 Days
Base Fee	$3,000 USD	**Delivery Mode**	Online / On-site Hybrid

Course Introduction

Training Course on Quantum Machine Learning Fundamentals provides a foundational understanding of Quantum Machine Learning (QML), an emerging field at the cutting edge of artificial intelligence and quantum computing. Participants will delve into the core principles of quantum mechanics, including superposition and entanglement, and explore how these concepts are harnessed to develop novel machine learning algorithms. The course bridges the gap between theoretical quantum concepts and practical AI applications, equipping learners with the essential knowledge and skills to navigate this transformative domain. We will explore the paradigm shift that QML offers, moving beyond classical computational limits to unlock unprecedented capabilities in data analysis, optimization, and pattern recognition, setting the stage for future breakthroughs in diverse industries.

As the convergence of quantum technology and machine learning accelerates, the demand for skilled professionals in QML is rapidly growing. This course is designed to empower data scientists, researchers, and developers with the expertise to leverage quantum advantage for complex computational problems. From understanding quantum gates and circuits to implementing variational quantum algorithms and exploring hybrid quantum-classical models, attendees will gain hands-on experience with leading QML frameworks. The curriculum emphasizes real-world applications and case studies, showcasing the potential of QML to revolutionize fields such as drug discovery, financial modeling, and materials science, preparing participants to contribute to the next generation of intelligent systems.

Programme Curriculum

Training Course on Quantum Machine Learning Fundamentals

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Course Duration

10 days

Course Objectives

1. Comprehend qubits, superposition, entanglement, and quantum gates as the bedrock of QML.
2. Understand and apply key VQAs like VQE and QAOA for optimization and machine learning tasks.
3. Design and execute solutions that leverage the strengths of both quantum and classical computation.
4. Develop and train QNN architectures for advanced pattern recognition and classification.
5. Learn methods to transform classical data into quantum states for quantum processing.
6. Gain proficiency in platforms such as Qiskit Machine Learning and PennyLane for QML development.
7. Identify and evaluate scenarios where QML can provide a demonstrable speedup or improved performance over classical methods.
8. Understand and mitigate the impact of noise and errors in current quantum hardware.
9. Solve complex combinatorial optimization challenges using quantum annealing and other QML techniques.
10. Leverage quantum-enhanced methods for improved data separation and classification.
11. Recognize the security landscape shifts brought by quantum computing and QML.
12. Employ quantum simulation tools to validate and test QML algorithms.
13. Stay abreast of emerging research and commercialization pathways in Quantum Artificial Intelligence.

Organizational Benefits

- Position your organization at the forefront of AI and computing advancements.
- Tackle previously intractable computational challenges in areas like drug discovery, financial risk, and materials science.
- Achieve faster and more efficient processing of large and complex datasets.
- Equip your teams with essential skills for the future of computing.
- Leverage QML to optimize processes, accelerate R&D, and create disruptive products/services.

- Understand the implications of quantum computing for cybersecurity and build quantum-resistant strategies.
- Drive internal innovation by exploring novel QML applications and methodologies.

8 Target Audience:

1. Data Scientists and Machine Learning Engineers
2. Computational Scientists and Researchers
3. Software Developers interested in quantum technologies
4. AI/ML Practitioners seeking advanced computational tools
5. Physicists and Mathematicians venturing into applied quantum computing
6. IT Professionals preparing for the quantum era
7. Innovation Managers and Technology Strategists
8. Graduate Students in Computer Science, Physics, or related fields

Course Outline

Module 1: Introduction to Quantum Computing for ML

- Fundamentals of Quantum Mechanics: Qubits, superposition, entanglement, and measurement.
- Classical vs. Quantum Computation: Understanding the inherent differences and potential advantages.
- Overview of Quantum Hardware: Introduction to different qubit technologies (superconducting, trapped ion, photonic).
- The Promise of Quantum Machine Learning (QML): Why QML is gaining traction.
- **Case Study:** Early applications of quantum algorithms for simple data classification tasks.

Module 2: Core Quantum Computing Concepts

- Quantum Gates and Circuits: Building blocks of quantum algorithms.
- Unitary Operations and Reversibility: Key properties of quantum computation.
- Measuring Quantum States: Understanding probabilistic outcomes.
- Density Matrices and Mixed States: Describing quantum systems.
- **Case Study:** Simulating simple quantum circuits for basic logical operations.

Module 3: Linear Algebra for Quantum Computing

- Vectors, Matrices, and Tensor Products: Mathematical tools for quantum states.
- Hilbert Spaces: The state space of quantum systems.
- Eigenvalues and Eigenvectors: Crucial for understanding quantum measurements and Hamiltonian simulation.
- Unitary Matrices: Representing quantum gates.
- **Case Study:** Representing and manipulating multi-qubit states using linear algebra.

Module 4: Introduction to Quantum Machine Learning

- Defining QML: The intersection of quantum mechanics and machine learning.
- Categories of QML Algorithms: Quantum-enhanced classical ML, quantum algorithms for ML, and quantum-inspired ML.
- Data Encoding in QML: Mapping classical data to quantum states (e.g., amplitude encoding, basis encoding).
- Noisy Intermediate-Scale Quantum (NISQ) Era: Challenges and opportunities of current hardware.
- **Case Study:** Encoding a simple dataset into qubits for a quantum algorithm.

Module 5: Quantum Algorithms for Supervised Learning

- Quantum Support Vector Machines (QSVMs): Leveraging quantum kernels for classification.
- Variational Quantum Classifiers (VQCs): Building trainable quantum circuits for classification.
- Quantum Nearest Neighbors (QkNN): Distance-based quantum algorithms.
- Training Quantum Models: Optimization strategies for parameterized quantum circuits.
- **Case Study:** Applying QSVM to a real-world dataset for improved classification accuracy.

Module 6: Quantum Algorithms for Unsupervised Learning

- Quantum Principal Component Analysis (QPCA): Dimensionality reduction in quantum settings.
- Quantum K-Means Clustering: Grouping data using quantum distance metrics.
- Quantum Generative Models: Exploring Quantum Boltzmann Machines and Quantum Circuit Born Machines.
- Anomaly Detection with QML: Identifying unusual patterns in data.
- **Case Study:** Using QPCA to reduce the dimensionality of a high-dimensional dataset for visualization.

Module 7: Variational Quantum Algorithms (VQAs)

- Parameterized Quantum Circuits (PQCs): The architecture of VQAs.
- Variational Quantum Eigensolver (VQE): Finding ground states of Hamiltonians, relevant for chemistry and materials.
- Quantum Approximate Optimization Algorithm (QAOA): Solving combinatorial optimization problems.
- Hybrid Quantum-Classical Optimization Loops: Combining quantum processing with classical optimizers.
- **Case Study:** Using VQE to simulate the energy of a simple molecule.

Module 8: Quantum Neural Networks (QNNs)

- Introduction to QNN Architectures: Different approaches to building quantum neural networks.
- Data Encoding Layers: Preparing input data for QNNs.
- Variational Layers and Entanglement: Building expressive quantum circuits.
- Measurement and Readout: Extracting classical information from QNNs.
- **Case Study:** Training a small QNN for image recognition on a quantum simulator.

Module 9: Quantum Optimization

- Combinatorial Optimization Problems: Traveling Salesperson Problem, Max-Cut.
- Quantum Annealing: A hardware-specific approach to optimization.
- Quantum Approximate Optimization Algorithm (QAOA): A gate-based VQA for optimization.
- Applications in Logistics and Supply Chain: Optimizing routes and resource allocation.
- **Case Study:** Applying QAOA to solve a small-scale supply chain optimization problem.

Module 10: Error Mitigation and Fault Tolerance

- Sources of Noise in Quantum Computers: Decoherence, gate errors.
- Error Mitigation Techniques: Mitigating noise in NISQ devices.
- Introduction to Quantum Error Correction (QEC): Towards fault-tolerant quantum computing.
- Impact of Noise on QML Algorithms: Understanding performance degradation.
- **Case Study:** Implementing a simple error mitigation technique on a noisy quantum simulator.

Module 11: QML Platforms and Frameworks

- Qiskit Machine Learning: IBM's open-source framework for QML.
- PennyLane: Xanadu's differentiable quantum programming library.
- TensorFlow Quantum: Google's integration of quantum computing with TensorFlow.
- Cloud-Based Quantum Services: Accessing quantum hardware (IBM Quantum, Azure Quantum, AWS Braket).
- **Case Study:** Developing a QML model using Qiskit and running it on a quantum simulator or a small quantum device.

Module 12: Real-World Applications of QML

- Drug Discovery and Materials Science: Simulating molecular interactions and discovering new materials.
- Financial Modeling: Portfolio optimization, risk assessment, fraud detection.
- Logistics and Supply Chain Management: Route optimization, resource allocation.
- Climate Modeling and Environmental Science: Simulating complex systems.
- **Case Study:** Discussing a hypothetical scenario where QML could accelerate drug discovery research.

Module 13: Quantum Machine Learning in Industry

- Industry Adoption and Roadmaps: Current state and future outlook.
- Challenges of Commercialization: Scalability, cost, and talent.
- Ethical Considerations in Quantum AI: Bias, fairness, and responsible development.
- Quantum-Inspired Algorithms: Classical algorithms leveraging quantum principles.
- **Case Study:** Analyzing a success story or ongoing project of QML deployment in a specific industry.

Module 14: Advanced Topics and Research Frontiers

- Quantum Reinforcement Learning: Applying QML to decision-making under uncertainty.
- Quantum Generative Adversarial Networks (QGANs): Generating complex data distributions.
- Quantum Natural Language Processing (QNLP): Exploring quantum approaches to language understanding.
- Benchmarking QML Algorithms: Measuring performance and quantum advantage.
- **Case Study:** Overview of a recent research paper in an advanced QML topic.

Module 15: Future of Quantum Machine Learning

- Fault-Tolerant Quantum Computing and QML: The long-term vision.
- Integration with Classical AI Ecosystems: Seamless workflows.
- Emerging Hardware Architectures and Their Impact: New developments in quantum hardware.
- Career Paths in QML: Opportunities for professionals in this evolving field.
- **Case Study:** Speculating on the transformative impact of QML in the next decade.

Training Methodology

This course will employ a blended learning approach, combining theoretical lectures with extensive hands-on programming exercises and interactive discussions. The methodology will include:

- **Lectures & Presentations:** Clear explanations of core quantum computing and machine learning concepts.
- **Interactive Demonstrations:** Live coding sessions showcasing QML frameworks and algorithms.
- **Hands-on Labs:** Practical exercises using Python with Qiskit, PennyLane, or TensorFlow Quantum for building and running QML models on simulators and cloud-based quantum hardware.
- **Case Study Analysis:** In-depth examination of real-world QML applications and their impact.

- **Group Discussions:** Fostering collaborative learning and problem-solving.
- **Q&A Sessions:** Opportunities for participants to clarify doubts and deepen understanding.
- **Project-Based Learning:** A culminating project where participants apply learned concepts to a practical QML problem.

Register as a group from 3 participants for a Discount

Send us an email: info@fineskilltrainingcenter.org or call *+254769199797*

Certification

Upon successful completion of this training, participants will be issued with a globally- recognized certificate.

Tailor-Made Course

We also offer tailor-made courses based on your needs.

Key Notes

a. The participant must be conversant with English.

b. Upon completion of training the participant will be issued with an Authorized Training Certificate

c. Course duration is flexible and the contents can be modified to fit any number of days.

d. The course fee includes facilitation training materials, 2 coffee breaks, buffet lunch and A Certificate upon successful completion of Training.

e. One-year post-training support Consultation and Coaching provided after the course.

f. Payment should be done at least a week before commence of the training, to Fineskill Training Center account, as indicated in the invoice so as to enable us prepare better for you.

Upcoming Scheduled Sessions

Start Date	End Date	Location	Price
23 Nov 2026	04 Dec 2026	Online	$2,000
23 Nov 2026	04 Dec 2026	Physical	$3,000
23 Nov 2026	04 Dec 2026	Physical	$6,000
23 Nov 2026	04 Dec 2026	Physical	$6,000
23 Nov 2026	04 Dec 2026	Physical	$12,000
23 Nov 2026	04 Dec 2026	Physical	$9,000

Start Date	End Date	Location	Price
23 Nov 2026	04 Dec 2026	Physical	$12,000
23 Nov 2026	04 Dec 2026	Physical	$12,000

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