Quantum Machine Learning

Code: CS31226CS	Course Type: Elective	Semester: II
Evolution Scheme (TA-MSE-ESE): 20-30-100	Total Marks: 150	L-T-P (Credits): 3-0-0 (3)

Pre-Requisites: Linear Algebra, Foundation of Quantum Computing

Course Objective: To provide students with the skillset necessary to tackle data problems into quantifiable quantum models, which will allow for implementation of quantum machine learning models for various problem.

Course Outcomes: At the end of the course, the student will be able to

CO-1	Understand the underlying Quantum Computing and its relevance to quantum machine learning.
CO-2	Translate classical data features into appropriate quantum states using various encoding techniques (e.g., Basis, Amplitude, Hamiltonian).
CO-3	Design, implement, and train Quantum Support Vector Machines and Quantum Neural Networks for classification and general machine learning tasks.
CO-4	Understand and Design Hybrid Algorithms for Quantum Machine Learning, and Quantum Generative Adversarial Algorithms.

Course Articulation Matrix:

PO	PEO-1	PEO-2	PEO-3	PEO-4	PEO-5
CO-1	1	2	3	1	3
CO-2	-	2	1	-	3
CO-3	3	3	1	-	2
CO-4	2	2	2	1	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit-1: Introduction to Quantum Computing

Introduction to Quantum Computing, Postulates of Quantum Mechanics, The Basics of Quantum Machine Learning, Rotational Gates, Overview of Qiskit and PennyLane API's for QML.

Unit-2: Data Encoding Techniques

Basis encoding, Amplitude encoding, Time evolution encoding, Hamiltonian Encoding, Data encoding as a Feature map. Training of a Quantum Machine Learning Model.

Unit-3: Quantum Machine Learning Models and Neural Networks

Variational Circuits as Machine Learning Models, Quantum Support Vector Machines – Basics of Support Vector Machine, Implementation of Support Vector Machines in Qiskit and PennyLane, Quantum Neural Networks – Building and Training a Quantum Neural Network, Implementation of Quantum Neural Networks in Qiskit and PennyLane.

Unit-4: Hybrid Algorithms for Quantum Machine –

Basics of Hybrid Quantum Machine Leaning, Hybrid Architecture in Qiskit and PennyLane, Quantum Generative Adversarial Networks – GANs and their Quantum counterparts, Quantum GANs in Qiskit and PennyLane.

Learning Resources:

Text Books:

1. Combarro, E. F., González-Castillo, A. D. M. S., & Di Meglio, A. (2023). A practical guide to quantum machine learning and quantum optimization. Packt Publishing.
2. Schuld, M., &Petruccione, F. (2021). Machine learning with quantum computers. Springer Nature Switzerland AG.
3. Nielsen, M. A., & Chuang, I. L. (2000). Quantum computation and quantum information. Cambridge University Press.