Hands-on Workshops on Quantum Cryptography and Quantum Machine Learning

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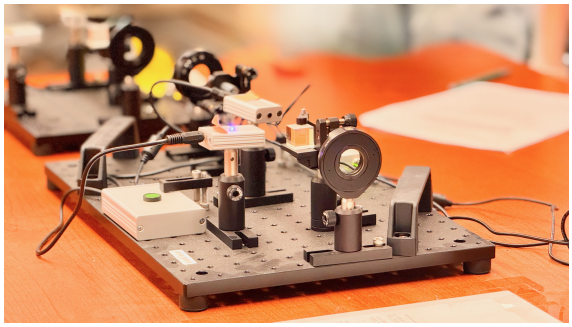

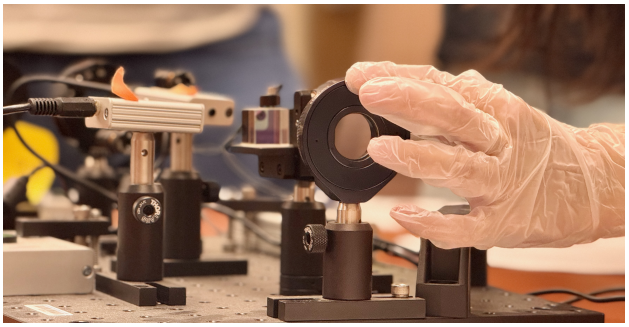

Workshop Overview

Quantum computing offers new approaches to solving computational problems, while sufficiently powerful quantum computers could break widely used encryption methods. These developments make it important for students to understand how quantum methods can support secure communication and machine learning, along with their practical limitations. These two 2.5-hour workshops provide that foundation through guided experiments in which students will use optical demonstrations to understand how a shared key is established and used to protect messages, examine how eavesdropping can introduce errors, and use IBM Quantum Classroom to build quantum circuits and train and evaluate an image classification model.

Workshop	Date	Time
Quantum Cryptography (QC)	11/06/2026	Session 1: 10:00 AM–12:30 PM Session 2: 01:30 PM–03:00 PM
Quantum Machine Learning (QML)	11/13/2026	10:00 AM–12:30 PM

Workshop 1 — Quantum Cryptography

Equipment: Thorlabs Quantum Cryptography Analogy Demonstration Kit.

This workshop introduces quantum cryptography through the BB84 quantum key distribution (QKD) protocol. Students will learn how the polarization of light can represent binary information, how communicating parties establish a shared key, and why measuring quantum states can reveal eavesdropping. Using the Thorlabs optical demonstration kit, participants will perform experiments that illustrate the principles of QKD and apply the resulting keys to encrypt and decrypt messages.

Topics: Polarization and measurement bases; quantum measurement and the no-cloning principle; BB84 protocol; key generation and sifting; one-time-pad encryption using XOR; eavesdropping and error detection.

Hands-on Activities:

- Simulate the BB84 protocol to understand bit transmission, measurement, and key sifting.
- Use the Thorlabs optical kit to examine how different polarization settings affect light transmission.
- Perform a BB84 demonstration, establish a shared key, and encrypt and decrypt a short message using XOR.
- Simulate an intercept-and-resend attack, compare the shared bits, and identify errors introduced by eavesdropping.

Session Format: Due to the limited availability of experimental equipment, the Quantum Cryptography workshop will be offered in two separate sessions.

Workshop 2 — Quantum Machine Learning

Platforms: IBM Quantum Classroom and Google Colab.

This workshop introduces the fundamentals of quantum computing and their applications to machine learning. Students will learn how quantum circuits represent and process information, how classical data can be encoded into quantum states, and how quantum and classical computations work together to train a machine learning model. Through a guided image classification experiment, participants will build, train, and evaluate a quantum classifier and examine its performance against a classical machine learning model.

Topics: Qubits and quantum states; superposition and entanglement; quantum gates, circuits, and measurement; quantum data encoding; parameterized quantum circuits; hybrid quantum-classical learning; image classification.

Hands-on Activities:

- Construct and execute basic quantum circuits using IBM Quantum Classroom to explore quantum gates and measurement.
- Prepare an image dataset and encode selected image features into quantum circuits.
- Implement and train a quantum image classifier using Google Colab and IBM quantum computing tools.
- Evaluate classification accuracy, compare results with a classical baseline, and discuss the capabilities and limitations of quantum machine learning.

Audience and Preparation: Open to students, researchers, and professionals interested in quantum computing and its applications. No prior knowledge of quantum computing is required. Basic Python programming and familiarity with machine learning are recommended for the QML workshop. Participants should bring a laptop with internet access for the QML activities.