Lahore University of Management Sciences

PHY 315, PHY5103, CS 316, EE 312
Introduction to Quantum Computing
Summer 2024

Instructor	Muhammad Faryad
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Office Hours	TBA in Class
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Course URL (if any)	www.lms.lums.edu.pk

Course Basics				
Credit Hours	3			
Lecture(s)	Nbr of Lec(s) Per Week	3	Duration	1:30 hours
Lab/Tutorial per week	Nbr of Session(s) Per Week	1	Duration	

Course Distribution	
Core	
Elective	Elective

COURSE DESCRIPTION

Quantum computers are the computers of the future because they seem to be much faster than the current computers for many tasks. Many companies like IBM, Google, Microsoft are investing heavily to develop quantum computers and are making them available in the cloud at the initial stage. This course will be your first introduction and hands-on interaction with quantum computers. We will learn designing quantum algorithms and implement them on actual quantum computers. The course is specifically designed for a broader group of students to introduce quantum computer programming without requiring any previous knowledge of quantum physics. We will study algorithms to solve practical problems like searching a database, factoring prime numbers, optimization, etc. and demonstrate the quantum advantage over currently used classical computers. The algorithms will be implemented using QISKIT package in Python and students will learn to write the programs and run them on IBM's quantum computers. This course will also cover all the syllabus of recently announced IBM's certification exam for quantum developers

COURSE PREREQUISITE(S)

Modern Physics

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Class Learning Outcomes	
	Students will learn how to 1- Develop basic quantum algorithms and turn them into programs to run on actual quantum computer. 2- Prove the quantum advantage using fundamental algorithms. 3- Apply quantum algorithms to solve searching and prime factoring problems. 4- Characterize and compare different quantum computers and analyze various sources of noises and errors in quantum measurements.

Grading Breakup and Policy
Assignments: 25% In-Class Activities: 25% Midterm: 25% Final: 25%

COURSE OVERVIEW

Modules	Topics	Recommended Readings	Objectives/ Application
1	Qubits, Quantum Measurements, Single Qubit Gates, Multiple Qubit Gates, Phase Kickback, Quantum Circuit Model of Computation, Introduction to QISKIT, Bloch and Q Spheres		
2	Entanglement, Qubit Teleportation, Deutsch—Jozsa, Bernstein—Vazirani, and Simon's algorithms demonstrating quantum advantage, Quantum Oracles, Programming IBM's Quantum Computer,		
3	Grover's Search Algorithm, Quantum Fourier Transform, Phase Estimation, Shor's Factoring Algorithm, HHL Algorithm for linear equations, Grover's Algorithm for Satisfiability Problems		
4	Superdense Coding, Quantum Key Distribution, Quantum Error Correcting Codes, Error Mitigation, Benchmarking Quantum Computers and Finding Quantum Volume,		

Textbook(s)/Supplementary Readings
There is no textbook. The following books will be used as references. Neilsen & Chuang, Quantum Computation and Quantum Information, 10th Anniversary Edition, (2010) Barnett, Quantum Information, (2008)

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Academic Policies

Academic Honesty/Plagiarism

LUMS has zero tolerance for academic dishonesty. Students are responsible for upholding academic integrity. If unsure, refer to the student handbook and consult with instructors/teaching assistants. To check for plagiarism before essay submission, use similarity@lums.edu.pk. Consult the following resources: 1) Academic and Intellectual Integrity (http://surl.li/gpvwb), and 2) Understanding and Avoiding Plagiarism (http://surl.li/gpvwo).

LUMS Academic Accommodations/ Petitions policy

Long-term medical conditions are accommodated through the Office of Accessibility & Inclusion (OAI). Short-term emergencies that impact studies are either handled by the course instructor or Student Support Services (SSS). For more information, please see Missed Instrument or 'Petition' FAQs for students and faculty (https://rb.gy/8sj1h)

Harassment Policy

LUMS Sexual Harassment Policy

LUMS and this class are a harassment-free zone. No behavior that makes someone uncomfortable or negatively impacts the class or individual's potential will be tolerated.

To report sexual harassment experienced or observed in class, please contact me. For further support or to file a complaint, contact OAI at oai@lums.edu.pk or harassment@lums.edu.pk. You may choose to file an informal or formal complaint to put an end to the offending behavior. You can also call their Anti-Harassment helpline at 042-35608877 for advice or concerns. *For more information: Harassment, Bullying & Other Interpersonal Misconduct: Presentation (http://surl.li/gpvwt)*

In addition to LUMS resources, SSE's **Council on Belonging and Equity** is committed to devising ways to provide a safe, inclusive and respectful learning environment for students, faculty and staff. To seek counsel related to any issues, please feel free to approach either a member of the council or email at cbe.sse@lums.edu.pk

Campus Supports

Students are strongly encouraged to meet course instructors and TA's during office hours for assistance in course-content, understand the course's expectations from enrolled students, etc. Beyond the course, students are also encouraged to use a variety of other resources. (Instructors are also encouraged to refer students to these resources when needed.) These resources include Counseling and Psychological Services/CAPS (for mental health), LUMS Medical Center/LMC (for physical health), Office of Accessibility & Inclusion/ OAI (for long-term disabilities), advising staff dedicated to supporting and guiding students in each school, online resources (https://advising.lums.edu.pk/advising-resources), etc. To view all support services, their specific role as well as contact information click here (https://advising.lums.edu.pk/#supportservices).

Rights and Code of Conduct for Online Teaching

A misuse of online modes of communication is unacceptable. TAs and Faculty will seek consent before the recording of live online lectures or tutorials. Please ensure if you do not wish to be recorded during a session to inform the faculty member. Please also ensure that you prioritize formal means of communication (email, lms) over informal means to communicate with course staff.