Lahore University of Management Sciences

CS 5112 / EE 539 / PHY 612 / PHY 417
An Introduction to Quantum Information Science and Quantum Technologies

Spring 2024

Instructor	Muhammad Faryad
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Office Hours	TBA in Class
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Course URL (if any)	
Support Services	LUMS offers a range of academic and other services to support students. These are mentioned below, and you are encouraged to use these in addition to in-class assistance from course staff. For a complete list of campus support services available for you click here (https://advising.lums.edu.pk/#supportservices)

Course Basics				
Credit Hours	3			
Lecture(s)	Nbr of Lec(s) Per Week	2	Duration	1:15 hours
Lab/Tutorial per week	Nbr of Session(s) Per Week		Duration	

Course Distribution	
Core	
Elective	Elective

COURSE DESCRIPTION

This course has two parts. The first deals with the basics of quantum computing. We will learn how to perform computations using simple quantum operations, called quantum gates. We will also build basic algorithms to show that quantum computers are faster than classical computers in solving some problems. The second part deals with quantum information that generalizes concepts from classical information theory. Using quantum information theory, we will then be able to understand quantum cryptography and noisy quantum processes. This will help us understand the limitations of current quantum computers due to noise. During the course, we will also spend some time on the physics of implementing single and two-qubit quantum gates.

COURSE PREREQUISITE(S)

Quantum Mechanics I

Class Learning Outcomes

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	Students will learn how to: 1- Do computing using quantum operations and see why it is faster than classical computers 2- Do basic quantum operations on single and two qubits to implement quantum gates 3- Use quantum information theory to understand information contents and do information processing

Grading Breakup and Policy
Assignments: 20% In-Class Activities: 20% Midterm: 30% Final: 30%

COURSE OVERVIEW

Modules	Topics	Recommended Readings	Objectives/ Application
1	Elements of Quantum Theory: Basic principles, Pure, mixed, and entangled states, qubits, unitary operators,	**Chapter 2, Barnett**	
2	Quantum Cryptography: Information security, quantum communication, Quantum key distribution	**Chapter 3, Barnett**	
3	Quantum Measurements: Ideal, non-ideal, and optimized measurements, Positive operator measures, Operations	**Chapter 4, Barnett**	
4	Entanglement: Non-locality, Ebits, Indirect measurements, Quantum dense coding and teleportation	**Chapter 5, Barnett**	
	Mid-Term Exam (March 7, 2024)		
5	Quantum Information Processing: Quantum gates and circuits, Error correction, Quantum computation basics,	**Chapter 6, Sections 7.1, and 7.2, Barnett**	
6	Quantum Information Theory: von Neuman entropy, Quantitative state comparison, Measures of entanglement, Quantum communication theory	**Chapter 8, Barnett**	
7	Physics of Quantum Computers: Implementation of one- and two-qubit gates	**Chapters 2 and 3, Stancil and Byrd**	
8	Noise: Decoherence, Characterizing gate errors, Noise mitigation	**Chapter 9, Stancil and Byrd**	
	Final Exam (May 7, 2024)		

Textbook(s)/Supplementary Readings
Textbooks: Barnett, Quantum Information, (2008). Stancil & Byrd, Principles of Superconducting Quantum Computers, (2022). Reference: Neilsen & Chuang, Quantum Computation and Quantum Information, 10th Anniversary Edition, (2010)

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Campus supports & Key university policies

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).

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)

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)*