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

Instructor: Muhammad Sabieh Anwar
TA: Abdullah Ijaz, Physics senior
Year: 2022-2023
Office: 9-103A
Email: sabieh@gmail.com
Semester: Spring
Office Hours:
Category: Undergrad/Grad
Course Code CS 5112 / EE 539 / PHY 612
**Course Title:** An Introduction to Quantum Information Science and Technologies
Credit hours: 1

Website: https://physlab.org/

Lecture format: Check the RO portal or Zambeel.

For Harassment policy and honor code, see the last sections of this outline.

_____

Course Description:

This course covers important topics in quantum information science and technological implementations. We will span the ideas of quantum information, quantum computing, quantum communication and cryptography, intreraction with machine learning and AI, as well as technological
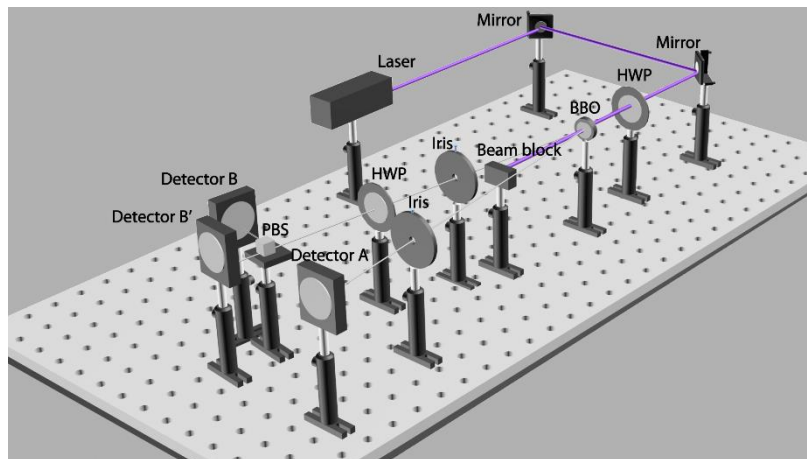
implementations. Some prior knowledge of quantum mechanics really helps (see preparatory notes below) but the course is designed to cater for all science and engineering students. It is not a survey, rather by using formative lectures, I will gradually build up the mathematical and conceptual tools that are necessary for appreciating the quantum revolution that is set to fundamentally change our view of the world around us. Furthermore, the course will incorporate some practical examples of running codes on an actual quantum computer. We will use the open-source SDK Qiskit: http://www.qiskit.org for working with quantum computers.

Pre-requisites:

No pre-requisite for graduate students. Undergraduates must have taken Modern Physics. If you know nothing about quantum mechanics or quantum computing, I believe this set of eight lectures on Youtube can really help: https://www.youtube.com/playlist?list=PLeG1bdj-IqXNNbSCbEHeq2AVvIIDocmqC.

Text books:

There is no set textbook. The best resources in this field, at the moment, are online courses. weeks 10-13, I will however employ parts of *Principles of Superconducting Quantum Computers*: https://www.amazon.com/Principles-Superconducting-Quantum-Computers-Stancil/dp/1119750725.

Grading scheme:

- Homeworks and computational assignments: 0% (feedback will be provided and tutorials conducted by the TA)
- Project 40% (will include an in-person presentation, *viva voce* and a written report)
- Midterm Exam 30%
- Final Exam 30%
- Grading will be absolute.
- The instructor has the liberty of varying these grade assignments by 10%.

Tentative Course Schedule & Topics:

Weeks	Topic	Some Particular Ideas
1-3	**Fundamentals of Quantum Information Science**	Quantum states, entanglement, the Bloch sphere, measurement, logic gates, quantum circuits
4-5	**Quantum Algorithms**	Deutsch, Search algorithms, factoring and basics of quantum cryptography, phase estimation, optimization
6	**Mid-Term week**	

7-9	**Quantum Communication**	Quantum key distribution protocols, quantum cryptography
10-13	**Quantum Technologies**	Practical implementations of quantum computer and communication networks, superconducting and photon-based implementations in particular, quantum sensing. We will also tour the single photon lab in Physlab: http://www.physlab.org/qmlab.
14-15	**Final exam and project presentations**	

Harassment Policy Harassment of any kind is unacceptable, whether it be sexual harassment, online harassment, bullying, coercion, stalking, verbal or physical abuse of any kind. Harassment is a very broad term; it includes both direct and indirect behaviour, it may be physical or psychological in nature, it may be perpetrated online or offline, on campus and off campus. It may be one offense, or it may comprise of several incidents which together amount to sexual harassment. It may include overt requests for sexual favours but can also constitute verbal or written communication of a loaded nature. Further details of what may constitute harassment may be found in the LUMS Sexual Harassment Policy, which is available as part of the university code of conduct. LUMS has a Sexual Harassment Policy and a Sexual Harassment Inquiry Committee (SHIC). Any member of the LUMS community can file a formal or informal complaint with the SHIC. If you are unsure about the process of filing a complaint, wish to discuss your options or have any questions, concerns, or complaints, please write to the Office of Accessibility and Inclusion (OAI, oai@lums.edu.pk) and SHIC (shic@lums.edu.pk) — both of them exist to help and support you and they will do their best to assist you in whatever way they can. To file a complaint, please write to harassment@lums.edu.pk.

Honor Code This course and all our interactions are based on the premise that students and I (Sabieh Anwar) will not resort to any means of taking unfair advantage of one another. I will not penalize any student unfairly and will not unduly advantage another. I will stick to norms of decency and mutual respect to my students. Similarly, students will also stick to an honor code---they will not cheat or help others cheat or plagiarize. I will not actively go out looking for plagiarism or cheating. However, if something comes to my notice, I will immediately refer this case to the School's Disciplinary committee for subsequent attention. **I will not invigilate exams.** I expect students to make their conscience their invigilator.