PHYS 459 "The Physics of Quantum Computing", Fall 2021
3 Credit Hours | Hybrid

Laurence Lurio, Professor, Department of Physics

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Other Methods of contact
Office Hours: Thursday 3-4
Microsoft Teams: By appointment
Office Location: FW 206

Course Meeting

TuTh 10:30 – 11:45 FR 237 Aug 24, 2021 - Dec 2, 2021

Students can participate in person, or remote via blackboard collaborate. Class sessions will be recorded using BB collaborate and posted on the class blackboard page for student review.

Course Description

Introduction to the principles of quantum computing, quantum computing algorithms, and the physical implementation of quantum computers.

Course Resources

Required Resources

- Required Texts: *Dancing with Qubits*, Robert S. Suter, Packt Publishing Lmt. 2019
- Optional Texts: *Quantum Computing for Everyone*, Chris Bernhardt, MIT Press. Covers similar material in a more concise way with less math (and consequently less detail)

Course Overview

Course Objectives (CO) and Related Assessments

Upon completion of this course, you should be able to:

- CO1: Distinguish how quantum computers work from how classical computing works. *Assessed with homework, student presentations and final paper.*
- CO2: Obtain facility with representing qubits using bra-ket notation. Use the principles of quantum mechanics to identify and distinguish between entangled and non-entangled states in one, two and three qubit systems: *Assessed with homework, written paper, and student presentation*
- CO3: Write a quantum computing program and execute it on the IBM Quantum Experience computer: *Assessed with quantum computer program*.

- CO4: Evaluate the current methods for physically achieving quantum computers used by leading quantum computing companies: *Assessed with Final Project.*

Assignment Overview

Assignment details are posted on the course site. The types of assignments you will complete include:

Homework Problems (20%)
These will include discussion and calculations.

Quantum Programming Project (20%)
These will include a programming project using the IBM Quantum Experience.

Midterm Exam (30%) (Group credit, 1 submission per group)
This will be an in class written exam. Students who cannot attend during regular class times must arrange with the instructor for an alternative exam date.

Presentations (15%) (Group credit, 1 submission per group)
Students will produce a 10 minute in-class presentation or video presentations evaluating a quantum computing company with a particular focus on the physical implementation.

Final Paper (15%) (Individual credit)
Students will write a report evaluating a quantum computing company with a particular focus on the physical implementation.

Grading Scale

A	=	93-100%
A-	=	90-92%
B+	=	87-89%
B	=	83-86%
B-	=	80-82%
C+	=	77-79%
C	=	73-76%
C-	=	70-72%
D	=	60-69%
F	=	0-59%

Course Calendar

Day	Date	Class Demos	Week	Module	Topic	Assig
Tuesday	24-Aug-21		1	1	Intro to quantum computing	

Thursday	26-Aug-21					
Tuesday	31-Aug-21		2	2	Classical Computers	
Thursday	2-Sep-21					Hom
Tuesday	7-Sep-21		3	3	Complex numbers	
Thursday	9-Sep-21					Hom
Tuesday	14-Sep-21		4		Matrices	
Thursday	16-Sep-21					Hom
Tuesday	21-Sep-21		5	3	Geometry	
Thursday	23-Sep-21	Electronic Logic				Hom
Tuesday	28-Sep-21		6		Matrices	
Thursday	30-Sep-21					Hom
Tuesday	5-Oct-21		7		Probability	
Thursday	7-Oct-21			4		Hom
Tuesday	12-Oct-21		8		Quantum Bits	
Thursday	14-Oct-21					
Tuesday	19-Oct-21	Polarization	9	5		
Thursday	21-Oct-21					Hom
Tuesday	26-Oct-21		10		Midterm Exam	
Thursday	28-Oct-21				Quantum Circuits	
Tuesday	2-Nov-21		11			
Thursday	4-Nov-21			6		
Tuesday	9-Nov-21	Atomic Spectra	12		Trapped Ion Qubits	Quan
Thursday	11-Nov-21					
Tuesday	16-Nov-21		13		Supercomputing Qubits	
Thursday	18-Nov-21	Superconducting SQUID		7		
Tuesday	23-Nov-21		14		Quantum error correction	
Thursday	25-Nov-21	No Class, Thanksgiving Break				
Tuesday	30-Nov-21		15		Student Presentations	Comp
Thursday	2-Dec-21	Last day of class			Student Presentations	

Course Guidelines

Time Commitment

Plan on spending roughly nine (9) hours a week on this course. This will vary by student, so you may spend a bit more and less, but it's a good guideline.

Course Communication

- **Course-wide communication** will most often come in the form of announcements through the Blackboard course site. New announcements will appear as a pop-up box when you enter the course and previous announcements will be available through a link on the left-hand navigation in the course site. I may use the Messages feature for quick reminders and check-ins and will respond to them when I am in the course site.

- **Instructor-initiated contact to individuals** will most often be done through the NIU email system.
- **For the quickest response from me**, email is the best way to reach out to me for the quickest response (as mentioned at the top of the syllabus). My goal is to respond to all emails within 24 hours during the work week. I may not be as readily available on the weekends.

Attendance and Participation

Attendance is expected either in person or synchronously online during the weekly class sessions. Students who expect to regularly miss sessions must make arrangements in advance with the instructor. Students can view recordings of sessions which will be made available on blackboard.

Late, Missed, and Makeup Work

If you cannot submit work by the due date, please contact me via email to arrange for a possible extension. Generally, students can get extensions on one or two late assignments before credit is deducted.

Academic Integrity Statement

"Good academic work must be based on honesty. The attempt of any student to present as his or her own work that which he or she has not produced is regarded by the faculty and administration as a serious offense. Students are considered to have cheated if they copy the work of another during an examination or turn in a paper or an assignment written, in whole or in part, by someone else. Students are guilty of plagiarism, intentional or not, if they copy material from books, magazines, or other sources without identifying and acknowledging those sources or if they paraphrase ideas from such sources without acknowledging them. Students guilty of, or assisting others in, either cheating or plagiarism on an assignment, quiz, or examination may receive a grade of F for the course involved and may be suspended or dismissed from the university."

Americans with Disabilities Statement

If you need an accommodation for this class, please contact the Disability Resource Center as soon as possible. The DRC coordinates accommodations for students with disabilities. It is located in the Campus Life Building, Suite 180, and can be reached at 815-753-1303 or drc@niu.edu.

Also, please contact me privately as soon as possible so we can discuss your accommodations. Please note that you will not be required to disclose your disability, only your accommodations. The sooner you let me know your needs, the sooner I can assist you in achieving your learning goals in this course.

Inclusivity Statements

- I am committed to making course content accessible to all students. If English is not your first language and this causes you concern about the course, please speak with me.
- Class rosters and University data systems are provided to faculty with the student's legal name and legal gender marker. As an NIU student, you are able to change how your preferred/proper name shows up on class rosters. This option is helpful for various student populations, including but not limited to: students who abbreviate their first name; students who use their middle name; international students; and transgender students.

Changes to the Syllabus

This syllabus is a guide, and every attempt is made to provide an accurate overview of the course and its requirements. However, certain circumstances may make it necessary for me to modify the syllabus during the semester for your benefit and the changes may depend, in part, on course progress and our needs. I will announce any change to the syllabus as early as possible so that you can adjust your schedule. The department/school will also be notified of any change.