PHYS 612: Quantum Information Physics
MW 2:30 – 3:30 PM, Fine Arts 301

Instructor:	Dr. Jason Kestner
Pre-reqs:	PHYS 601
Office:	Physics 316
Office Hours:	F 2:30–3:30 PM, or just stop by anytime, or email to schedule
Email:	jkestner@umbc.edu
Textbook:	*Quantum Computation and Quantum Information*, Nielsen & Chuang
Resources:	Preskill's lectures (www.theory.caltech.edu/people/preskill/ph229)
	Quantum Computer Science: An Introduction, Mermin
	Explorations in Quantum Computing, Williams (free ebook)
	IBM Q Experience (www.research.ibm.com/ibm-q/)

Course Description

This course gives an introduction to the fundamental concepts of quantum information processing with an emphasis on the physics of its implementation. The focus is on the nascent field of quantum computing, with some results in quantum communication discussed as well.

Since this is the first time the course is being offered, the structure may evolve over the semester to best meet your needs (your input will have a big impact here!). However, my plan is to run the class sessions more like a book club or an informal tutorial than a lecture, with me as your expert (or in any case, fearless) guide. Obviously, in order for you to benefit, it is **imperative** for you to **read** the assigned sections before each class. I am counting on you to do so. We will generally follow the classic textbook of Nielsen & Chuang, though for some sections we may toggle over to Preskill or another reference.

Academic Objectives

By the semester's end, you should be able to demonstrate understanding of

- In what way a quantum computer is expected to provide exponential improvement over a classical computer.
- Basic quantum algorithms, such as Deutsch-Josza, Grover, and Shor.
- The basic idea of quantum error correction.

- The physics of the various types of qubits currently being researched.
- Basic ideas of quantum cryptography.
- Outstanding physics challenges that must be overcome to realize the quantum technology revolution.

Assignments

Extensive readings will be assigned before each class. It is essential that you actually do read them. To help motivate this, there will be accompanying short questions due for credit at the beginning of each class.

In addition, homeworks will be assigned semi-regularly. The work you turn in must be self-contained, logical, and neat.

Individual study is necessary to internalize the concepts, but group study is a good way to overcome roadblocks. However, all submitted work must be your own. Copied or paraphrased work is unacceptable.

You may use Mathematica or other software freely. When you do so, attach a printout to your homework.

Final Project

Each student will choose a final project topic in consultation with the instructor. Topic selections are due before Spring Break. A written paper will be due at the end of the semester, as well as an oral presentation to the class.

Overall Grades

Your course grade will be determined by the following components:

Homework	50%
Reading questions	20%
Final project oral	10%
Final project written	20%

This course will not be graded on a curve. Total scores translate to grades in the following way:

Score	Grade
90–100	A
88–90	A-
85–88	B+
81–85	B
78–81	B-
75–78	C+
71–75	C
68–71	C-
65–68	D
0–65	F

Course schedule (subject to change)

Idea and algorithms
Week 1 Overview, Deutsch-Josza algorithm, and complexity classes (Chaps. 1, 2)
Week 2 Quantum circuit model and universality (Chap. 4)
Week 3 Quantum Fourier Transform and its applications (Chap. 5)
Week 4 Grover's algorithm and its applications (Chap. 6)
Fault tolerance
Week 5 Shor code (Chap. 10)
Week 6 Stabilizer codes (Chap. 10)
Physical implementations
Week 7 Photonic qubits (Chap. 7)
Week 8 Trapped ion qubits (Chap. 7)
Week 9 Spin qubits
Week 10 Superconducting qubits
Week 11 Quantum annealers
Other topics
Week 12 Quantum cryptography: BB84 protocol (Chap. 12)
Week 13 Certified random number generators
Week 14 TBD
Week 15 Project presentations

Academic Integrity

By enrolling in this course, each student assumes the responsibilities of an active participant in UMBC's scholarly community in which everyone's aca-

demic work and behavior are held to the highest standards of honesty. Cheating, fabrication, plagiarism, and helping others to commit these acts are all forms of academic dishonesty, and they are wrong. Academic misconduct could result in disciplinary action that may include, but is not limited to, suspension or dismissal. To read the full Student Academic Conduct Policy, consult the UMBC Student Handbook or the UMBC Policies section of the UMBC Directory.