PHY/MATH 6480: Introduction to Quantum Computing

Course Syllabus: **Fall 2019**

Instructors:
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Meeting times
TBD (3 hours/week)

Office Hours
TBD

Course Synopsis
This cross-listed course will serve as an introduction to quantum computing. The course aims at bringing together students with different backgrounds in mathematics, physics, chemistry, and computer science to foster interdisciplinary connections in the areas of quantum computing and quantum information.

Prerequisites
A strong background in linear algebra over the complex numbers as well as differential and integral calculus is required. Familiarity with quantum physics and complexity theory will be helpful, but it is not required.

Learning Outcomes
By the end of the course students should be able to:

1. Understand the basis of quantum mechanics needed for the implementation of quantum bits (qubits)
2. Know how to manipulate qubits by using quantum gates
3. Design simple quantum algorithms
4. Become familiar with current and proposed physical realizations of quantum computers, their potential, and their limitations
5. Apply the basic principles of quantum computing to create and execute quantum codes in quantum computing simulators and an actual quantum computer
6. Understand basic schemes for quantum error corrections

Text
The main textbook used will be *Quantum Computation and Quantum Information* by Nielsen and Chuang. Another recommended, although not required, textbook is *A First Introduction to Quantum Computing and Information* by B. Zygelman.

Other Resources
Free, open-source quantum computing simulators such as the Microsoft Quantum and IBM QISKit Development Kits will be used throughout the course. The IBM Q Experience, a cloud-based platform, will be used to interact with a real quantum computer housed in an IBM Research lab. Each student will need a computer to create and execute codes and simulations.

Exams
There will be no exams in this course. The final grade will rely on the completion of homework, weekly online quizzes and a final project.

Homework assignments
Problems will be assigned each week, and collected one week later in class. In addition, an online quiz evaluating fundamental concepts will be scheduled each week. Homework and due dates will be posted to Canvas. No late homework will be accepted as solutions will be automatically posted on Canvas after the deadline. No credit will be given for work that is obviously copied from another student. Any copying or plagiarizing will be considered cheating, resulting in no credit and, possibly, university-level disciplinary actions (https://doso.wayne.edu/pdf/student-code-of-conduct.pdf).

Final Project
All students will be required to participate in a final project and present it to the rest of the class. Students will work on the final project individually or in a small group, in dependence of the complexity and extension of the project.

Grading
The course grade has the following components:

70% - Homework Problems + Quiz Sets, after dropping the lowest individual score.
30% - Final Project.

The course grade will be assigned according to the total number of percentage points as follows:

A	A-	B+	B	B-	C+	C	C-	D+	D	D-	F
90-100	85-89	80-84	75-79	70-74	65-69	60-64	55-59	50-54	45-49	40-44	0-39

Undergraduate vs. Graduate Students
University regulations require that course work and grading be independent for undergraduate and graduate students. Graduate students will complete exercises, homework, and projects with higher level of complexity. As there are no grades lower than C for graduate students, graduate students will receive a fail grade if they garner less than 66% of the total score of the course.

Policy on Missed Work
The grading scheme, dropping the lowest individual score, and allowing for a missed homework set, will accommodate routine illness and personal contingencies.

Generally, if a student is registered for the course a regular grade will be given. A grade of incomplete (I) will be given only in exceptional cases (to accommodate illness or emergency) after consultation with the Instructors before the end of term.

Add/Drop Dates
Please, refer to WSU's Academic and Registration Calendar (http://reg.wayne.edu/students) for the University add and drop dates. Note: Failing to drop a class by a deadline may hurt your GPA, financial aid status, and/or your tuition bill.

Academic dishonesty
All of the graded assignments are designed to measure your individual understanding of the material. No forms of cheating on any graded assignments will be tolerated. Students are encouraged to work together on the homework via small study groups. However, each student is required to write their own homework report without copying or plagiarizing others. Any copying or plagiarizing will be considered cheating, resulting in no credit and, possibly, university-level disciplinary actions (https://doso.wayne.edu/pdf/student-code-of-conduct.pdf). Your homework may be checked for plagiarism with SafeAssign.

Student Disability Services
If you have a documented disability that requires accommodations, you will need to register with Student Disability Services for coordination of your academic accommodations. The Student Disability Services (SDS) office is located at 1600 David Adamany Undergraduate Library in the Student Academic Success Services department. The SDS telephone number is 313-577-1851 or 313-202-4216 for videophone use. Once you have met with your disability specialist, I will be glad to meet with you privately during my office hours to discuss your accommodations. Student Disability Services' mission is to assist the university in creating an accessible community where students with disabilities have an equal opportunity to fully participate in their educational experience at Wayne State University. You can learn more about the disability office at www.studentdisability.wayne.edu.

To register with Student Disability Services, complete the online registration form at:
https://wayne-accommodate.symplicity.com/public_accommodation/

WSU Resources for Students
- Student Disability Services (SDS) http://studentdisability.wayne.edu/
- Academic Success Center http://www.success.wayne.edu/
- Counseling and Psychological Services (CAPS) http://www.caps.wayne.edu
- Dean of Students' Office http://www.doso.wayne.edu
- College of Liberal Arts & Sciences: https://clas.wayne.edu/students
- Departmental Website: http://physics.clas.wayne.edu//

Class Schedule
A tentative class schedule is provided in the next page.

Class Schedule: Introduction to Quantum Computing (Fall 2019)

Week	Topic
1	Classical computers, logic gates, Turing machines, and complexity theory: An overview
2	Review of linear algebra
3	The postulates of Quantum Mechanics: from bits to qubits
4	Physical realizations of qubits: spins, ion traps, superconducting qubits
5	Quantum teleportation and superdense coding
6	Quantum gates and universality
7	Quantum computing simulators: Microsoft quantum development kit
8	Quantum algorithms
9	Quantum Computing simulators: IBM QISKit development kit
10	The IBM Q Experience approach to quantum computing
11	Quantum error corrections
12	Current proposed architectures for quantum computation and their limitations
13	Fault-tolerant topological quantum computing
14	Work on Final Project
15	Final Project Presentations