PHYS/CS 463: Quantum Computing

My favorite topic! An introduction to qubits, quantum gates, quantum circuits, quantum entanglement and Bell inequalities, quantum teleportation, superdense coding, quantum key distribution, Grover's search algorithm, quantum phase estimation, Shor's factoring algorithm, and quantum error correction.

Open to all students with a working knowledge of linear algebra (PHYS 220 or MATH 221). A background in quantum mechanics is not required. In fact, most of the topics in this course are nearly orthogonal to the topics covered in a traditional quantum mechanics course. (You *do* need to know what "orthogonal" means!) Besides learning the theory, you will do remote experiments with real quantum processors via IBM Quantum.

Textbook: I'm very excited to use an excellent new textbook, free as an ebook:

https://www.thomaswong.net/introduction-to-classical-and-quantum-computing-1e3p.pdf

Despite the author's disclaimer in the preface, this textbook is **not** too elementary!

Grades will be computed as follows:

20% each of 3 tests

5% each of 5 lab reports (based on remotely accessed quantum processor)

15% final lab report on Shor's algorithm (in lieu of final exam)

Problem sets are ungraded but are **essential** practice for the tests.

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	Tentative Topic	Reading (chapter sections)	Prob. Set	Due
Jan 18	Qubits	1.1.5, 2.1-2.3	1	
Jan 23	Quantum circuits	1.2.1, 2.4-2.7	2	
Jan 25	Linear algebra	3	3	
Jan 30	Multiple qubits	4.1-4.2	4	
Feb 1	Controlled gates	1.2.2, 4.3-4.4	5	
Feb 6	Quantum adder	1.3, 4.5	6	
Feb 8	Lab 1: Quantum adder	5.1-5.2		
Feb 13	Test 1			
Feb 15	Quantum entanglement	6.2	7	
Feb 20	Lab 2: CHSH inequality			Lab 1
Feb 22	Quantum protocols	6.4-6.5, 6.6.3	8	
Feb 27	Deutsch's algorithm	7.1-7.3	9	
Feb 29	Grover's algorithm	7.6.1-7.6.3	10	
Mar 5	Grover circuit	7.6.4	11	
Mar 7	Lab 3: Grover's algorithm			Lab 2
Mar 19	Quantum database	Kain, Am. J. Phys. 89, 618–626	12	
Mar 21	Test 2			
Mar 26	Quantum Fourier Transform	7.7	13	
Mar 28	Lab 4: QFT			Lab 3
Apr 2	Quantum phase estimation	7.8	14	
Apr 4	Lab 5: Phase estimation			Lab 4
Apr 9	Modular exponentiation	7.9	15	
Apr 11	Shor's algorithm	7.10	16	
Apr 16	Final Lab: Shor's algorithm			Lab 5
Apr 18	Test 3			
Apr 23	RSA cryptosystem	6.6.2		
Apr 25	Quantum error correction	4.7		
May 2				Final Lab