

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 recent textbook, free as an ebook:

<https://www.thomaswong.net/introduction-to-classical-and-quantum-computing-1e4p.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 14	Qubits	1.1.5, 2.1-2.3	1	
Jan 21	Quantum circuits	1.2.1, 2.4-2.7	2	
Jan 26	Linear algebra	3	3	
Jan 28	Multiple qubits	4.1-4.2	4	
Feb 2	Controlled gates	1.2.2, 4.3-4.4	5	
Feb 4	Quantum adder	1.3, 4.5	6	
Feb 9	Lab 1: Quantum adder	5.1-5.2		
Feb 11	Test 1			
Feb 16	Quantum entanglement	6.2	7	
Feb 18	Lab 2: CHSH inequality			Lab 1
Feb 23	Quantum protocols	6.4-6.5, 6.6.3	8	
Feb 25	Deutsch's algorithm	7.1-7.3	9	
Mar 2	Grover's algorithm	7.6.1-7.6.3	10	
Mar 4	Grover circuit	7.6.4	11	
Mar 16	Lab 3: Grover's algorithm			Lab 2
Mar 18	Quantum database	Kain, Am. J. Phys. 89, 618-626	12	
Mar 23	Test 2			
Mar 25	Quantum Fourier Transform	7.7	13	
Mar 30	Lab 4: QFT			Lab 3
Apr 1	Quantum phase estimation	7.8	14	
Apr 6	Lab 5: Phase estimation			Lab 4
Apr 8	Modular exponentiation	7.9	15	
Apr 13	Shor's algorithm	7.10	16	
Apr 15	Final Lab: Shor's algorithm			Lab 5
Apr 20	Test 3			
Apr 22	RSA cryptosystem	6.6.2		
Apr 27	Quantum error correction	4.7		
May 4				Final Lab