

# Spring 2024 CS 593 / MA 595

## Intro to Quantum Computing

### Weekly Calendar ([back to homepage](#))

	Tuesday	Thursday	Homework
Week 1	<p>1/9/24. Logistics. Getting to know each other. Course overview. Hilbert spaces, Cauchy-Schwarz, triangle inequality, adjoints, Hermitian/self-adjoint operators, unitary operators, normal operators, unitary diagonalizability, spectral theorem (finite dimensional case).</p> <p>Reading: front matter, Chapter 1, Sections 2.1.1-2.1.6 from Nielsen and Chuang</p> <p><a href="#">Notes</a></p>	<p>1/11/24. Proof of spectral theorem, examples of Hilbert spaces, qubits, qudits, Pauli operators.</p> <p>Reading: 2.1.7-2.1.9</p> <p><a href="#">Notes</a></p>	<p><a href="#">Homework 1</a>, due Friday 1/19 at 8pm on Brightspace</p>
Week 2	<p>1/16/24. Bras and kets, tensor products and outer product, simultaneous diagonalization</p> <p>Reading: Sections 2.1.7-2.1.9</p> <p><a href="#">Notes</a></p>	<p>1/18/24. Axioms of quantum mechanics</p> <p>Reading: Section 2.2</p> <p><a href="#">Notes</a></p>	<p><a href="#">Homework 2</a>, due Monday 1/29 at 8pm on Brightspace</p>
Week 3	<p>1/23/24. (Projective) measurement, measuring in computational basis and quantum state tomography, distinguishing states, Heisenberg uncertainty</p>	<p>1/25/24. Quantum circuits.</p> <p>Note: Since this is a graduate CS course, I am skipping chapter 3. But I strongly</p>	<p>nada</p>

	<p>principle, global phases and complex projective space.</p> <p>Unfortunately I don't think we will have time to cover POVMs or more general measurements right now, nor will we have time to cover mixed states and density operators. But please read about these things. There is a good chance we will come back to them later.</p> <p>Reading: Section 2.2</p> <p><a href="#">Notes</a></p>	<p>encourage everyone to read it.</p> <p>Reading: starting Chapter 4</p> <p><a href="#">Notes</a></p>	
<b>Week 4</b>	<p>1/30/24. Universal gate sets.</p> <p>Reading: Sections 4.1-4.5.3</p> <p><a href="#">Notes</a></p>	<p>2/1/24. Solovay-Kitaev theorem, BQP.</p> <p>Reading: 4.5, 4.6, Appendix 3</p> <p><a href="#">Notes</a></p>	<p><a href="#">Homework 3</a>, due Monday, 2/5 at 8pm on Brightspace.</p>
<b>Week 5</b>	<p>2/6/24. Some high level overview of quantum algorithms. Teleportation. Deutsch-Jozsa.</p> <p>Reading: Chapter 1</p> <p><a href="#">Notes</a></p>	<p>2/8/24. This was kind of a "clean-up" day where we covered a smattering of random topics: no cloning, super dense coding, Bernstein-Vazirani, BQP in PSPACE.</p> <p>Reading:</p> <p><a href="#">Notes</a></p>	<p><a href="#">Homework 4</a>, due Monday, 2/19 at 8pm on Brightspace. Only problems 1 and 7 will be graded for correctness. Other problems will be graded for completeness. UPDATE: don't do problem 5 or 7(b). Also, for 1(c), only do the "easy" direction. See my Brightspace announcement for more info.</p>

<b>Week 6</b>	<p>2/13/24. Grover's algorithm</p> <p>Reading: starting chapter 6</p> <p><a href="#">Notes</a></p>	<p>2/15/24. Extensions of Grover's algorithm. Grover lower bounds.</p> <p>Reading: second half of Chapter 6</p> <p><a href="#">Notes</a></p>	nada
<b>Week 7</b>	<p>2/20/24. Algebra interlude. Groups, representations, Fourier transforms.</p> <p>Reading: Appendix 2.</p> <p><a href="#">Notes</a></p>	<p>2/22/24. Quantum Fourier transforms.</p> <p>Reading: 5.1, 5.2</p> <p><a href="#">Notes</a></p>	
<b>Week 8</b>	<p>2/27/24. Quantum simulation</p> <p>Reading: 4.7.</p> <p><a href="#">Notes</a></p>	<p>2/29/24. We watched a seminar talk as a class today.</p>	<a href="#">Homework 5</a> , due Monday, 4/4 at 8pm on Brightspace.
<b>Week 9</b>	<p>3/5/2024. Phase estimation and QMA.</p> <p>Reading: Section 5.2 of Nielsen-Chuang, and Section 14 of Kitaev-Shen-Vyalyi</p>	<p>3/7/2024. QMA and the local Hamiltonian problem.</p> <p>Reading: Section 14 of Kitaev-Shen-Vyalyi</p>	
<b>Spring break</b>			
<b>Week 10</b>	<p>3/19/2024. Simon's problem.</p> <p>Reading: Section 13 of Kitaev-Shen-Vyalyi</p>	<p>3/21/2024. The first part of Shor's algorithm: reducing factoring to order finding.</p> <p>Reading: Chapter 5 and Appendix 4 of Nielsen-Chuang, or Section 13 and</p>	Homework 6: see announcement on Brightspace. Due Monday, 4/25 at 8pm.

		Appendix of Kitaev-Shen-Vyalyi	
<b>Week 11</b>	<p>3/26/2024. The second part of Shor's algorithm: quantum algorithm for order finding.</p> <p>Reading: Chapter 5 and Appendix 4 of Nielsen-Chuang, or Section 13 and Appendix of Kitaev-Shen-Vyalyi</p>	<p>3/28/2024. Remarks on hidden subgroup problem.</p>	<p><a href="#">Homework 7</a>, due Friday, 4/5 at 8pm on Brightspace.</p>
<b>Week 12</b>	<p>4/2/2024. Quick intro to error correction. Classical repetition code. Phase flip and bit flip codes.</p> <p>Reading: 10.1 of Nielsen-Chuang</p>	<p>4/4/2024. Mixed states</p> <p>Reading: Section 2.4 of Nielsen-Chuang</p>	nada
<b>Week 13</b>	<p>4/9/2024. Quantum operations/channels. Quantum error correction conditions.</p> <p>Reading: Chapter 8 of Nielsen and Chuang</p>	<p>4/11/2024. Intro to Pauli stabilizer codes.</p> <p>Reading: 10.5 of Nielsen and Chuang</p>	nada
<b>Week 14</b>	<p>4/16/2024. The additive nature of Pauli stabilizer codes. Classification in terms of isotropic subspaces of symplectic vector spaces over field with 2 elements.</p>	<p>4/18/2024. Computing the distance and the rate of a Pauli stabilizer code. Definition of toric code.</p>	<p><a href="#">Homework 8</a>, due Friday, 4/26 at 8pm on Brightspace. This is the last homework of the semester. It is "quasi-optional." (Read the pdf for more info.)</p>
<b>Week 15</b>	<p>4/23/2024. Computing rate and distance of toric code.</p>	<p>4/25/2024. Last day of class. Final comments. Ask me anything.</p>	