The course meets MWF 1:00-2:00 online. I will be giving synchronous lectures, which will be recorded. I plan to do an experiment — for a half-hour of one of the three lectures each week, I will have a discussion period where people can ask questions, and we can discuss the material. We can vote as to which of the days this will be on at our first class meeting. I’d rather reserve this time for discussions of the course material, and discuss homework during office hours.

**Syllabus:** I plan to go through the material faster than Prof. Lloyd did when he taught the course, but slower than Prof. Chuang did. My current outline of what we will be covering is at the end of this document. There are five units, and each unit will be between one and three weeks. I don’t know exactly how long each unit will be (I could use previous years as a guide to try to figure out the timing, but I’ve rearranged the material and added some material to some of the units, so if I did this I’d probably calculate incorrectly.

**Grading:** There are several components to your grade:

- two “takehome” midterms (15% each), and one final (20%).
- homework: 50%.

**Exams:** There will be two midterm exams, one on October 7 and one on November 6. These will be open book — you can use any resources you want, except that you are not allowed to ask people for help.

**Homework:** There will be weekly problem sets. You can turn in psets 24 hours late for a 10% penalty. Without a note from S³, late psets will not be accepted after the solutions are posted, which we plan to do 24 hours after they are due.

**Collaboration:** Collaboration on homework is encouraged. However, please write up your solutions on your own. The purpose of the homework is for you to learn the material, and getting help from somebody will let you learn it better than staring at a blank piece of paper for hours trying to figure out a way to attack the problem. (I plan to give a few tricky exercises, but I don’t intend to give you exercises where there’s no way to figure out how to proceed — if I do, please complain.) You must list all collaborators on every assignment. If you make significant use of some resource other than the textbook, please note this on your homework, as well. If you have no collaborators, please state that on your assignment, too.

**Piazza:** There is a piazza for this course. I, the TAs, and any other students who want to will be responding to questions that you ask on it. I plan to check it daily, not hourly, so if you have an urgent question, email me (not that I check my email hourly, either).

**Problem Set Collaborators:** Andrew Sutherland is developing a pset partner website that will help you find pset collaborators remotely. I encourage you to use it.
Student Support Services (S³): If you are dealing with a personal or medical issue that is impacting your ability to attend class, complete work, or take an exam, please discuss this with S³. Their friendly staff provides support and advice, as well as advocacy and consultation with faculty, administration, housing, financial services, and other offices on your behalf. The deans in S³ will verify your situation, and discuss with you how to address the missed work. For an extension on a pset longer than a day or two, you will need to get the support of S³.

Student Disability Services: MIT is committed to the principle of equal access. Students who need disability accommodations are encouraged to speak with Kathleen Monagle, Associate Dean, prior to or early in the semester so that accommodation requests can be evaluated and addressed in a timely fashion. Not sure if you have a disability? Many students do not get diagnosed until college. SDS staff members can help you and determine your next steps. Theresa Cummings in MAS (Math Academic Services) can help arrange the logistics of student disability accommodation.

Detailed Syllabus:

Unit 1 Qubits

- qubits — polarizations and spins.
- Pauli matrices
- Operations on qubits — unitary matrices
- Measurements on qubits (von Neumann measurements and Hermitian observables)
- The Bloch sphere
- interferometers
- The Elitzur-Vaidman bomb tester
- Measurements on qubits.
- Wiesner’s quantum money.

Unit 2: The Classical Gate Model of Computation

- Boolean formulas
- The universality of AND, OR and NOT gates
- the invisible gate — FAN-OUT
- reversible computation
- linear Boolean formulas
- The Toffoli gate (and possibly the Fredkin gate).

Unit 3 More than One Qubit
– Joint states and tensor products
– entanglement
– EPR pairs and Bell States
– Two-qubit gates (The CNOT gate in particular)
– Partial measurement (measuring one qubit out of many)
– Teleportation
– Superdense coding
– The Clifford group
– The EPR paradox and Bell’s Theorem
– The GHZ paradox
– Density matrices and the partial trace

Unit 4: Quantum Algorithms

– The Deutsch-Jozsa Algorithm
– The Factoring Algorithm, and maybe the Discrete Log algorithm
– Grover’s Algorithm

Unit 5 Quantum Error Correcting Codes

– The 9-qubit code
– CSS codes
– The BB84 quantum key distribution protocol
– CSS code proof of security of BB84.