

C191A Midterm 2 Study Guide

Logistics

The second midterm for C191A: Introduction to Quantum Computing (Fall 2025) will be next Thursday, the 20th of November, during normal class time (2:00pm - 3:30pm). To adequate for space, if your last name starts with:

- [A-S] please refer to the classroom Soda #306.
- [T-Z] please refer to the Hearst memorial mining building #410.

You may bring **two** A4 sheet of handwritten notes (both sides). This allows you to bring your cheat sheet for midterm 1, plus an additional new one, or two new sheets. Formula sheets will be provided on the exam.

Overview

The exam consists of 3 problems. You will have 80 minutes to complete the exam. Review the following major topics carefully and work through example problems.

1. Mixed States, Density Matrices

- Expressing mixed states using density matrices
- Computing measurement probabilities, for density matrices measured in any projective bases.
- Computing post measurement states after measurements.
- Following the evolution of a mixed state through a short circuit and computing measurement outcomes.
- Trace, partial trace, reduced density matrices.
- Pure vs mixed states, purity, Bloch-vector representation.

2. Error-Correcting Codes, Stabilizer Formalism

- Classical repetition code: error detection vs correction, majority decoding, failure probabilities.
- Shor 9-qubit code, concatenation, protecting from X - and Z -errors.
- Stabilizer codes: definition, generators, syndrome measurement, logical operators.
- Compute syndromes from commuting/anticommuting Pauli operators.
- Understand circuits implementing Stabilizer Codes.

- Understand the notion of distance.

3. Quantum Algorithms and the Quantum Fourier Transform

- Understand all the quantum algorithms and subroutines seen in lecture and in the homeworks.
- Make sure to understand the concepts and gain intuition for how they work.
- Review the properties of the QFT in detail, including applications to periodic superpositions, computing resulting amplitudes, and measurement probabilities; in addition to basic properties of roots of unity.

Preparation Checklist

- Review all the homeworks and practice problems, covering the above topics.
- Work through calculations by hand: measurements, trace-outs, syndrome computations, applying QFT to periodic states.
- Create your cheat sheet: summarize all key formulas relevant to the above topics.
- Practice circuits: draw small circuit evolutions, compute state vectors or density matrices, including measurements and partial trace-outs.