# Quantum Information B  Fall 2020  Final Exam

Solutions are due in by 4 pm on **Monday Dec 28**, return them in Moodle. Let me know if you find typos. I extended the deadline in case you are overburdened before Christmas holidays. All problems in part I are taken from Nielsen-Chuang, look them up from the book. You can use all available sources, but if you happen to find a solution somewhere, do not copy it without understanding every step.

**Part I: Exercises**

Choose **3 problems** from the 5 alternatives below to solve.

1. Exercise 8.15 from the book. enkai00
2. Exercise 8.24 from the book.
3. Exercise 9.10 from the book
4. Exercise 10.9 from the book.
5. Exercise 10.70 from the book.

**Part II: Essay**

Write a 3-4 page essay (use your own judgment on the appropriate length) on **one** of the topics below. The topics are in no particular order. The idea is the present the topic as you would be lecturing or teaching it to your fellow students. Below every topic there is a reference suggestion to get you started. Google for more references, according to your taste.

- **Qiskit** is an open-source framework for quantum computing, for creating quantum programs which can be run on prototype devices on IBM Q Experience.
  Referece suggestion: `https://qiskit.org/learn`
- **Variational Quantum Eigensolver (VQE)** is a quantum algorithm based on the Ritz variational principle for finding the ground state wavefunction ofthe Schrödinger equation. This is of particular interest for the study of molecules and quantum chemistry.
  Reference suggestions: `https://pennylane.ai/qml/demos/tutorial_vqe.html`
  `https://qiskit.org/textbook/ch-applications/vqe-molecules.html`
  `https://arxiv.org/abs/2004.01372`
- **Surface Codes** are quantum error correction codes that are advangegous for quantum hardware platforms, requiring only nearest-neighbor interactions. They are not very difficult to learn the basics of, after learning about stabilizer codes.
  Reference suggestion: J. Roffe: "Quantum Error Correction: An Introductory Guide", arXiv:1907.11157

- **The HHL algorithm**, named after its inventors Aram Harrow, Avinatan Hassidim, and Seth Lloyd, is a quantum algorithm for solving linear systems of equations. Reference suggestions: `https://en.wikipedia.org/wiki/Quantum_algorithm_for_linear_systems_of_equations`
`https://qiskit.org/textbook/ch-applications/hhl_tutorial.html`

- **Shannon's noisy channel coding theorem**: see Nielsen and Chuang, section 12.2.1 p. 537, to get started

- **Entanglement distillation and entanglement dilution**: see Nielsen and Chuang, section 12.5.3 p. 580, to get started

- **Interesting topic of your own choice** (subject to my approval prior to writing)