

Exercise: Quantum Computing
Problem set 3 (to be discussed in week of May 20, 2019)

Problem 1 Matrix Representation of Quantum Fourier Transform

In the lecture we discuss the Quantum Fourier Transform defined through its action

$$|x\rangle \rightarrow \frac{1}{\sqrt{2^N}} \sum_{k=0}^{2^N-1} e^{2\pi i x k / 2^N} |k\rangle$$

on the basis states $|x\rangle \in \{|0\rangle, \dots, |2^N - 1\rangle\}$ with number of qubits N . Give a matrix representation for $N = 3$.

Problem 2 Quantum Fourier Transform and Elementary Gates

We have established previously how to relate a general gate operation to only the single-qubit H , R_ϕ , and the two-qubit CNOT gates. How many H , R_ϕ , and CNOT gates, respectively, are required to implement the Quantum Fourier Transform circuit given in the lecture?

Problem 3 Quantum Fourier Transform is Unitary

Show that the Quantum Fourier Transform is unitary.

Problem 4 Inverse Quantum Fourier Transform

In the lecture we give a quantum circuit to perform the Quantum Fourier Transform. Give a circuit to perform its inverse operation.

Problem 5 Simulation of Quantum Fourier Transform (optional)

Implement the Quantum Fourier Transform for general N in the simulator <http://github.com/lehner/sqc>. Using this implementation, perform the Quantum Fourier Transform for $N = 3$ on all basis vectors.