CS269Q: Quantum Programming **Spring 2019**

Project #1

Due: 11:59pm on Mon., Apr 29 2019, by Gradescope

Problem 1. Benchmarking a Quantum Computer

In this project you will use pyQuil to benchmark a quantum processor. Rather than using a real QPU for the assignment you will use a simulated one to practice your code with. Your code will then be tested against other simulated processors.

The QPUs you are bench marking has **5 qubits** with the following natural gate set:

(a) NOISY-I which applies a noisy I

(b) NOISY-RX-PLUS-180 which applies a noisy RX(π)

(c) NOISY-RX-PLUS-90 which applies a noisy RX($\pi/2$)

(d) NOISY-RX-MINUS-180 which applies a noisy RX($-\pi$)

(e) NOISY-RX-MINUS-90 which applies a noisy RX($-\pi/2$)

(f) NOISY-CZ which applies a noisy CZ

(g) RZ(θ)

All single qubit gates in the above list are available on every qubit and all pairs of qubits can have the NOISY-CZ applied to them, e.g. NOISY-CZ 2 4 applies a CZ with noise to control qubit 2 and target qubit 4.

You are told that the durations of the single qubit gates are 50 nanoseconds and the durations of the two qubit gates are 100 nanoseconds.

Accompanying this assignment sheet is a *benchmark.ipynb* file that is a template showing you how to load and apply the provided *noise_model.quil* file. In the following sections, your task is to load the noise model from the file and then write benchmarking programs that charecterize the performance of the simulated QPU with that model. If this were a real QPU you would just run your code against that processor backend directly.

In order to be graded correctly, your submitted code must include a *benchmark.py* file with the appropriate functions as described below.

a. Write a function in benchmark.py called benchmark_T1 whose single argument is the string name of the noise model file and whose output is a dictionary whose keys are qubit ids and whose values are the T1 coherence time of those qubits in seconds, e.g.:
{Q0: 1e-6, Q1: 6e-7, ... }

b. Write a function in benchmark.py called benchmark_T2 whose single argument is the string name of the noise model file and whose output is a dictionary whose keys are qubit ids and whose values are the T2 coherence time of those qubits in seconds, e.g.:
{Q0: 0.5e-6, Q1: 4e-6, ... }

You have been distributed an example noise model file that you can test against while you are developing your solution. This file is called *noise_model.quil*. Here are the charecteristics of that noise model:

(a) t1s = {0: 10e-6, 1: 10e-6, 2: 14e-6, 3: 1e-6, 4: 5e-6}

(b) t2s = {0:2e-6, 1:10e-6, 2:14e-6, 3:0.5e-6, 4:5e-6}