CSCE 785, Fall 2024, Homework 3
Due Wednesday October 9 at 11:30pm

1 Written Exercises

Do Exercises 2.21, 2.24, 2.30, 2.36, 2.37, 2.45, 2.48, 2.51.
Do Exercises 3.1, 3.4, 3.5, 3.7.

2 Programming Exercises

A note about pricing. If you keep the number of shots below 500, running a circuit on a QPU becomes *much* cheaper. 500 is the threshold where error mitigation algorithms kick in, and these are expensive. A small circuit running with 500 shots or more will cost $97.50, most of which is overhead as increasing the size of the circuit does not increase this value very much. Keeping the number of shots below 500 may cost as low as $12.42 (thank you, Ian). For our purposes, 100–200 shots is plenty to gather meaningful statistics.

For this exercise you will build a series of four 2-qubit circuits to test Deutsch's problem:

1. For each of the four Boolean functions $f : \{0,1\} \to \{0,1\}$ you can construct an f-gate $f_{1,2}$ on qubits 1 and 2 as follows:

the constant 0 function	(no gates)
the constant 1 function	X_2
the identity function	C-$X_{1,2}$
the negation function	X_2C-$X_{1,2}$ (or C-$X_{1,2}X_2$, either way)

2. Embed $f_{1,2}$ into the Deutsch circuit: X_2 followed H_1H_2 on the left (applied first), followed by $f_{1,2}$, followed by H_1 then a measurement gate on qubit 1.

3. Run each of the four circuits on IonQ's simulator, setting the noise model to `aria-1` and the number of shots to 100.

4. Report the resulting measurement probabilities for each of the four circuits.