Lab 1: Intro to Quantum Programming with Qiskit

Preliminaries

Refer to teaching materials in Week 1.

Requirements for Lab Reports

The requirements stated below apply to this lab and all future labs for this subject.

A lab report should be written as a Jupyter Notebook, which should have the following structure:

1. The lab title, your student ID, and your full name: included in a Markdown cell.
2. Labelled answers to lab tasks: Your labels should match the labels in the lab tasks. Each label should be introduced by a Markdown cell, which should also contain a brief description of the task. After this Markdown cell with label, you can use as many Markdown or Code cells as needed to answer the task. If a task contains hierarchical labels, such labels should be used in your Notebook as well.

In submitting the lab report, you should convert it to pdf first, which can be done by clicking the 'File' menu in Jupyter Notebook, and then clicking 'Download As' → 'PDF via HTML (pdf)'. This feature of Jupyter should be available in our lab computers. To enable this feature in your PC, you need to install Python's notebook-as-pdf package by following the steps below:

1. Run Anaconda Powershell Prompt as Administrator.
2. Run 'pip install -U notebook-as-pdf'. NB: Some dependency errors could be displayed in the end, but they can be ignored.
3. Run 'pyppeteer-install'.

Before submitting the pdf report to vUWS, double check to make sure it contains the complete answers (code, results, plots, etc.) to lab tasks.

Tasks

Before attempting the tasks below, you should fully understand every step in our Jupyter NB01 Hello World.

Write your answers for all tasks to your lab report.

1. Start an Anaconda Powershell Prompt. Note that you need to run it as Administrator. This can be done by right clicking the 'Anaconda Powershell Prompt' icon and then selecting the 'Run as Administrator' option. In this prompt, enter the directory where you want to store the notebook for this lab. Then, type the command 'jupyter notebook', which will invoke a web interface for you to create/edit the notebook. Name your notebook for this lab 'Lab01-YourSID.ipynb'.

   NB: This task doesn't need an answer in the lab report.

2. Use a code cell to print out the versions of the elements in your Qiskit installation. Then, use a Markdown cell to explicitly answer the versions for the following elements:
   - Qiskit
   - Qiskit-terra
   - Qiskit-aer

3. Create a simple quantum circuit with measurement and visualization by following the steps below.
   3.1 Import all necessary packages.
   3.2 Create a circuit with 2 input qubits and 2 output bits.
   3.3 Apply h() gate to q_0, apply x() gate to q_1, and finally apply cx() gate to q_0 and q_1.
   3.4 Measure q_0 and q_1, and store the measurement results into bits 0 and 1 respectively.
   3.5 Visualize this circuit.

4. Run the above quantum circuit with a QasmSimulator for 2000 shots and plot the result with a histogram. The expected result is that '01' and '10' should each appear with about 50% probability, and '00' and '11' won't appear.

5. Run the above quantum circuit with a real IBM quantum computer by following the steps below.
   5.1 Create an account at the IBM quantum website, and retrieve your API token. Store this token into your local qiskit installation by calling IBMQ.save_account().
   5.2 Find a least busy real computer.
   5.3 Run the circuit with this computer for 1200 shots and plot the result with a histogram.
   5.4 Explain why you see '00' and '11' appear in some shots in a Markdown cell.