King Fahd University of Petroleum and Minerals

College of Computing and Mathematics
Computer Engineering Department
COE 530: Quantum Computer & Architecture

Programming Assignment 1

Due date: Monday 21-2-2026

Objective

The objective of this programming assignment is to get familiar with your favorite quantum SDK to implement a 3-bit ripple carry adder that adds two 3-bit binary numbers. The assignment is divided into tasks. This assignment should be completed **individually**.

Reading References

- Chapter 5 "Quantum Programming" in "Introduction to Classical and Quantum Computing"

Description

It is highly recommended to complete the tasks in order only after getting your self familiar with your favorite Quatnum SDK. If you feel lazy, you can start with IBM Qiskit by reading Chapter 5 of the Introduction to Classical and Quantum Computing textbook.

1. (Half Adder) Implement the Half Adder (HA) circuit that takes two bits (e.g. a and b) using IBM Q. Take a screenshot of the circuit for each possible input combination, i.e., a=0 b=0, a=0 b=1, a=1 b=0, and a=1 b=1.

2. Take a screenshot of the outputs of one of the circuits in part (1). Explain how to interpret the output from the "Statevector" and "Probabilities" figures in IBM Q.

3. (Full Adder) Implement the Full Adder (FA) circuit that takes, in addition to two bits (a and b), a carry-in bit (e.g. c_{in}). Repeat the same procedure in part (1) and (2).

4. Now, instead of assigning a particular value for a (i.e., 0 or 1), put the qubit that represents bit a in a superposition state and observe the output state. Explain how to interpret the output from the "Statevector" and "Probabilities" figures in IBM Q in this case.

5. Run the FA circuit on any available quantum hardware and take a screenshot of the job's output.

6. Implement a 3-bit Ripple-Carry Adder using the circuit we covered in the class. Note that the circuit composer doesn't allow to run circuits with more than 6 qubits. Therefore, you have to implement the circuit using IBM Qiskit and run it on IBM Quantum lab. (You may implement this circuit using the Circuit Composer, but you need to execute it using Quantum Lab).

7. Using your implementation in the previous task, use the 3-bit ripple carry adder to add two 3-bit numbers (e.g. A and B), where A and B are based on your IDs. In particular, A is equal to mod 8 of the sum of the rightmost two digits in your ID, while B is mod 8 of the sum of the following two digits. For example, if your ID is 200325710 then $A = 1{+}0 = 1$ mod $8 = 1$ and $B = 7{+}5{=}11$ mod $8 = 3$. The circuit should calculates the binary addition of 1 and 3 in binary.

Deliverables

- Executable source code of all the quantum circuits. Points will be deducted (partially or full) if the code is not executed.

- In addition to the source code of all of your circuits, you also need to submit a brief write-up including the screenshots and explanation of the resulting figures.