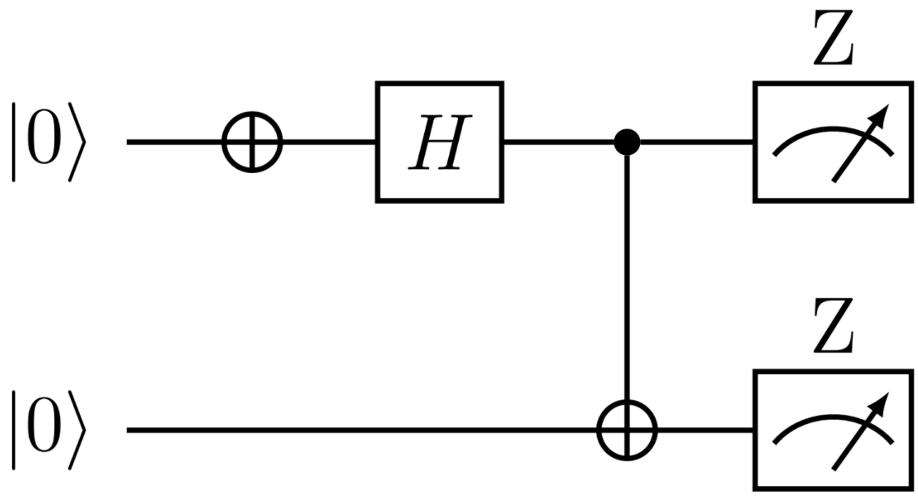
Python Deep Dive IP
Quantum Computing using Python Assignment

Q1. Create this circuit using Qiskit SDK by IBM.



Which of the following closest matches the probability of measuring the bit string $|11\rangle$?

(a). 100% (b). 50% (c). 25% (d). 0%

Which of the following closest matches the probability of measuring the bit string $|10\rangle$?

(a). 100% (b). 50% (c). 25% (d). 0%

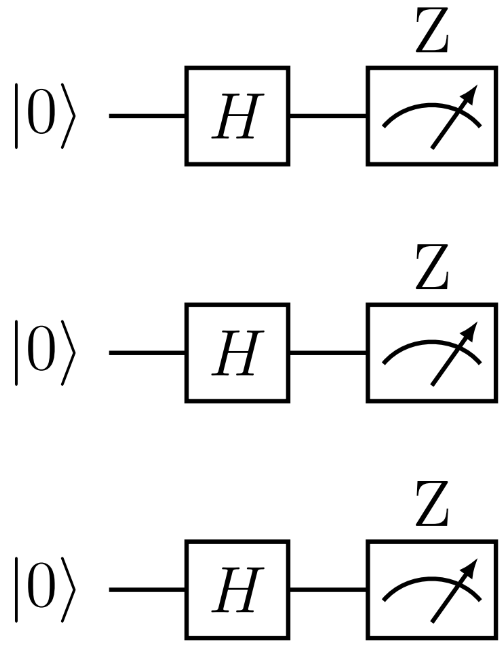
What is the probability that both bits are the same (i.e. the probability of measuring $|00\rangle$ OR $|11\rangle$)?

(a). 100% (b). 50% (c). 25% (d). 0%

What is the probability that the bits are different (i.e. the probability of measuring $|11\rangle$ OR $|10\rangle$)?

(a). 100% (b). 50% (c). 25% (d). 0%

Q2. Create this circuit using Qiskit SDK by IBM.



Which of the following closest matches the probability of measuring the bit string $|000\rangle$?

(a). 100% (b). 50% (c). 25% (d). 12.5%

Which of the following closest matches the probability of measuring the bit string $|011\rangle$?

(a). 100% (b). 50% (c). 25% (d). 12.5%

In how many different can one arrange 3 bits (000,001,010, etc.)?

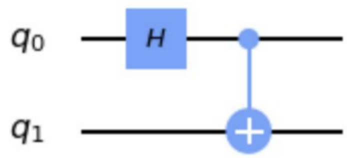
(a). 4 (b). 8 (c). 16 (d). 32

After running the circuit in the simulator, which of the following bit strings is not measured at all?

(a). All arrangements of 3 bits are possible measurements.

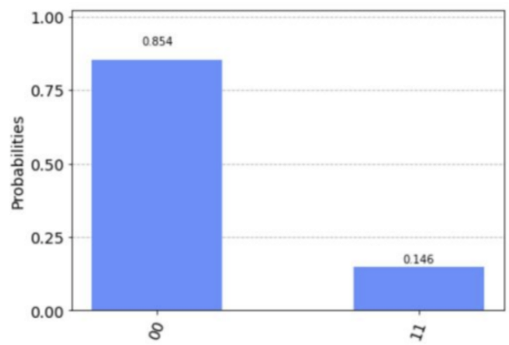
(b). $|101\rangle$ (c). $|001\rangle$ (d). $|110\rangle$ (e). $|111\rangle$

Q3. What is the following circuit representing?

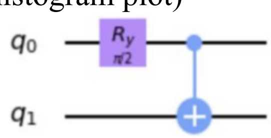


(a). A 2 qubit circuit with a Hadamard gate on the first qubit and a CNOT gate with the q0 qubit as the target and q1 as the control.
(b). Two qubits placed in a superposition
(c). A qubit encoding known as the “Rick Purnell Maneuver”
(d). A Single qubit circuit with a bit flip and then a Hadamard gate applied.

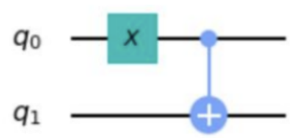
Q4. What circuit could create the following probability histogram?

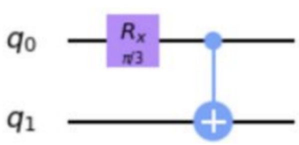


(Note: We are not interested in getting the same probability values but in replicating the nature of the histogram plot)

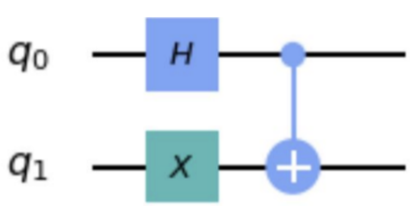
(a). 

(b). 

(c). 

(d). 

Q5. What Bell state does the following circuit create?



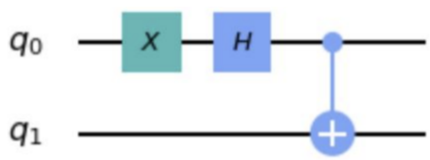
(a). $|\Phi^+\rangle = \frac{1}{\sqrt{2}}(|00\rangle + |11\rangle)$

(b). $|\Phi^-\rangle = \frac{1}{\sqrt{2}}(|00\rangle - |11\rangle)$

(c). $|\Psi^+\rangle = \frac{1}{\sqrt{2}}(|01\rangle + |10\rangle)$

(d). $|\Psi^-\rangle = \frac{1}{\sqrt{2}}(|01\rangle - |10\rangle)$

Q6. What Bell state does the following circuit create?



(a). $|\Phi^+\rangle = \frac{1}{\sqrt{2}}(|00\rangle + |11\rangle)$

(b). $|\Phi^-\rangle = \frac{1}{\sqrt{2}}(|00\rangle - |11\rangle)$

(c). $|\Psi^+\rangle = \frac{1}{\sqrt{2}}(|01\rangle + |10\rangle)$

(d). $|\Psi^-\rangle = \frac{1}{\sqrt{2}}(|01\rangle - |10\rangle)$

Q7. Using NumPy to solve for Psi, which of the following represents the resulting NumPy state vector of Psi:

$$|\Psi\rangle = \left(\left(\begin{bmatrix}1\\0\end{bmatrix} \otimes \begin{bmatrix}1\\0\end{bmatrix}\right) \otimes \begin{bmatrix}0\\1\end{bmatrix}\right) \otimes \begin{bmatrix}1\\0\end{bmatrix}$$

(a). Psi = np.array([[0], [0], [0], [0], [0], [0], [0], [0], [0], [0], [0], [0], [0], [0], [0], [0]])
(b). Psi = np.array([[0], [1], [0], [0])
(c). Psi = np.array([[0], [0], [0], [0], [1], [0], [0], [0]])
(d). Psi = np.array([[0], [0], [1], [0], [0], [0], [0], [0], [0], [0], [0], [0], [0], [0], [0], [0]])

Now, give the value of the state vector of Phi:

$$CNOT = \begin{bmatrix}1 & 0 & 0 & 0\\0 & 1 & 0 & 0\\0 & 0 & 0 & 1\\0 & 0 & 1 & 0\end{bmatrix}$$

$$I = \begin{bmatrix}1 & 0\\0 & 1\end{bmatrix}$$

$$U = (I \otimes I) \otimes CNOT \qquad |\Phi\rangle = U|\Psi\rangle$$

(a). Psi = np.array([[0], [0], [0], [1], [0], [0], [0], [0], [0], [0], [0], [0], [0], [0], [0], [0]])
(b). Psi = np.array([[0], [0], [0], [1], [0], [1], [0], [1], [0], [0], [0], [0], [0], [1], [0], [0]])
(c). Psi = np.array([[0], [0], [0], [0], [0], [0], [0], [0], [0], [0], [0], [0], [0], [0], [0], [1]])
(d). Psi = np.array([[0], [0], [1], [0], [0], [0], [0], [0], [0], [0], [0], [0], [0], [0], [0], [0]])

Q8. Using the following definitions and the knowledge that:

starting state Psi = $|0010\rangle$ and final state Phi = $|0011\rangle$

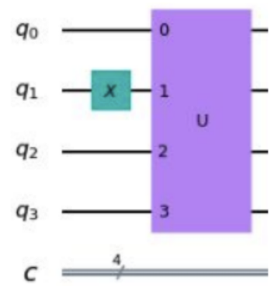
Remember also that we are right indexing, so Qubit 0 is on the right, and Qubit 3 is on the left. Therefore, $|0001\rangle$ means that Qubit 0 is 1

Which of these circuits is functionally equivalent to the U circuit shown in the question:

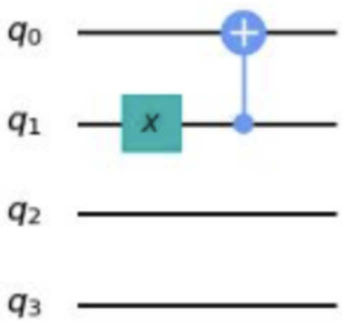
$$CNOT = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

$$I = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

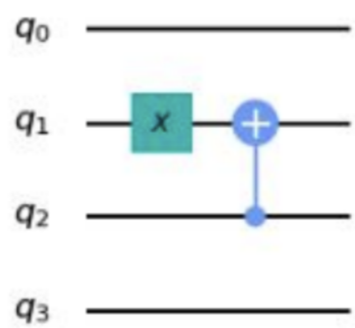
$$U = (I \otimes I) \otimes CNOT \qquad |\Phi\rangle = U|\Psi\rangle$$



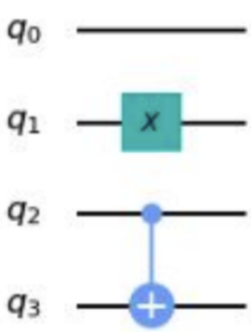
(a).



(b).



(c).



(d).