Getting Started with Qiskit

Qiskit consist of two stages: Build the circuit and Execute the circuit

Download and Import Libraries

In [ ]:
```
!pip install numpy
!pip install qiskit
```

In [36]:
```
import numpy as np
from qiskit import *
```

Build the circuit

In [28]:
```
cir= QuantumCircuit(3)
```

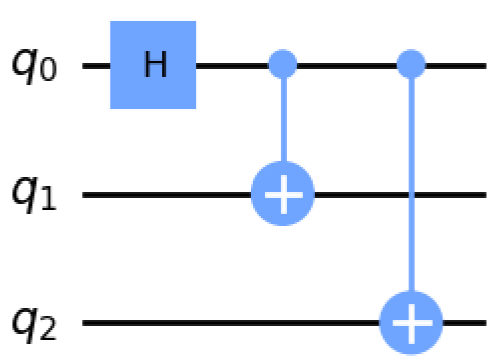
In [29]:
```
cir.h(0)
cir.cx(0,1)
cir.cx(0,2)
```

Out[29]:
```
<qiskit.circuit.instructionset.InstructionSet at 0x1d9689eee50>
```

Circuit Visualization

In [34]:
```
cir.draw('mpl')
```

Out[34]:



Simulating the circuit

State Vector Backend

- **Calculates the statevector that represents the quantum circuit.**
- **The statevector describes the probability amplitudes of all possible states of the quantum circuit.**
- **Useful for analyzing and simulating small quantum circuits.**
- **Supports measurements and classical control operations, but cannot simulate the effects of noise or errors in the quantum hardware.**

In [8]:
```
from qiskit import Aer
```

In [11]:
```
backend= Aer.get_backend('statevector_simulator')
job= backend.run(cir)
```

In [35]:
```
result= job.result()
```

In [108]:
```
backend_sim= Aer.get_backend('qasm_simulator')
job_sim= backend_sim.run(transpile(qc,backend_sim), shots=1024)
result_sim= job_sim.result()
counts= result_sim.get_counts(qc)
print(counts)
```

```
{'111': 496, '000': 528}
```

Get the vector for the quantum circuit

In [21]:
```
outputstate =result.get_statevector(cir,decimals=3)
print(outputstate)
```

```
Statevector([0.707+0.j, 0.   +0.j, 0.   +0.j, 0.   +0.j, 0.   +0.j,
             0.   +0.j, 0.   +0.j, 0.707+0.j],
            dims=(2, 2, 2))
```

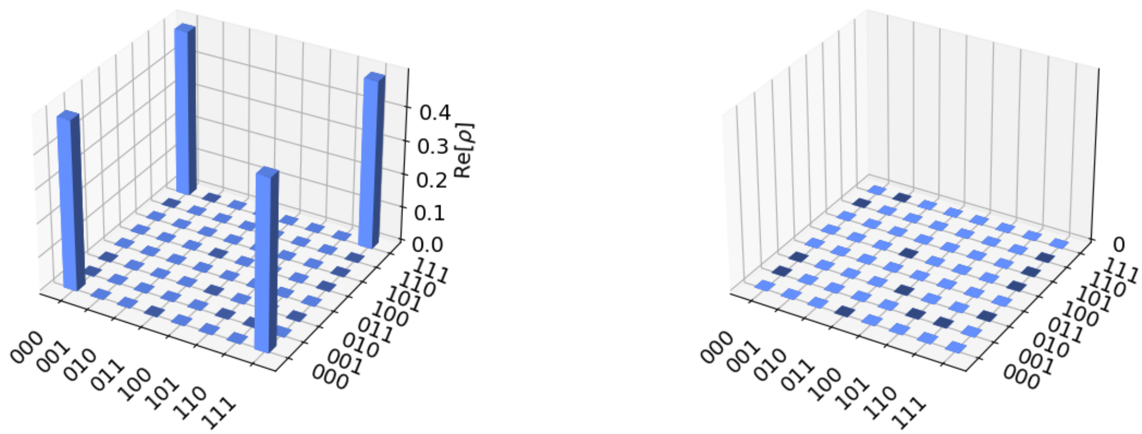
Visualization of the state density matrix

- The density matrix is a matrix representation of the quantum state.
- The state density matrix describes the quantum state of a system in a mixed state (i.e., a probabilistic mixture of pure states).
- The density matrix is a matrix representation of the quantum state.
- The density matrix can be visualized using a heat map, where the color of each cell represents the magnitude and phase of the corresponding matrix element.
- The diagonal elements of the density matrix represent the probabilities of measuring the system in a specific state.
- Off-diagonal elements represent the coherence between different states.

- The density matrix can be visualized using a 3D plot, where the x and y axes represent the states, and the z-axis represents the magnitude and phase of the corresponding matrix element.
- Visualization of the density matrix can aid in understanding the properties of a quantum system, such as entanglement and coherence.
- The state tomography technique can also be used to reconstruct the density matrix from measurement data, which can be visualized using the techniques mentioned above.

In [73]:
```
from qiskit.visualization import plot_state_city
plot_state_city(outputstate)
```

Out[73]:



Mathematical representation of the quantum circuit

->: **state.draw('latex') This line generates a visualization of the resulting state using LaTeX notation. The output is a LaTeX code snippet that can be rendered as a mathematical expression in a LaTeX document or typesetting system.**

In [62]:
```
from qiskit.quantum_info import Statevector
#set initial state of simulator to the ground state using init
state= Statevector.from_int(0,2**3)
state= state.evolve(cir)
state.draw('latex')
```

Out[62]:
$$\frac{\sqrt{2}}{2}|000\rangle + \frac{\sqrt{2}}{2}|111\rangle$$

->: **Matrix in a visually appealing format**

In [65]:
```
from qiskit.visualization import array_to_latex
array_to_latex(state)
```

Out[65]:

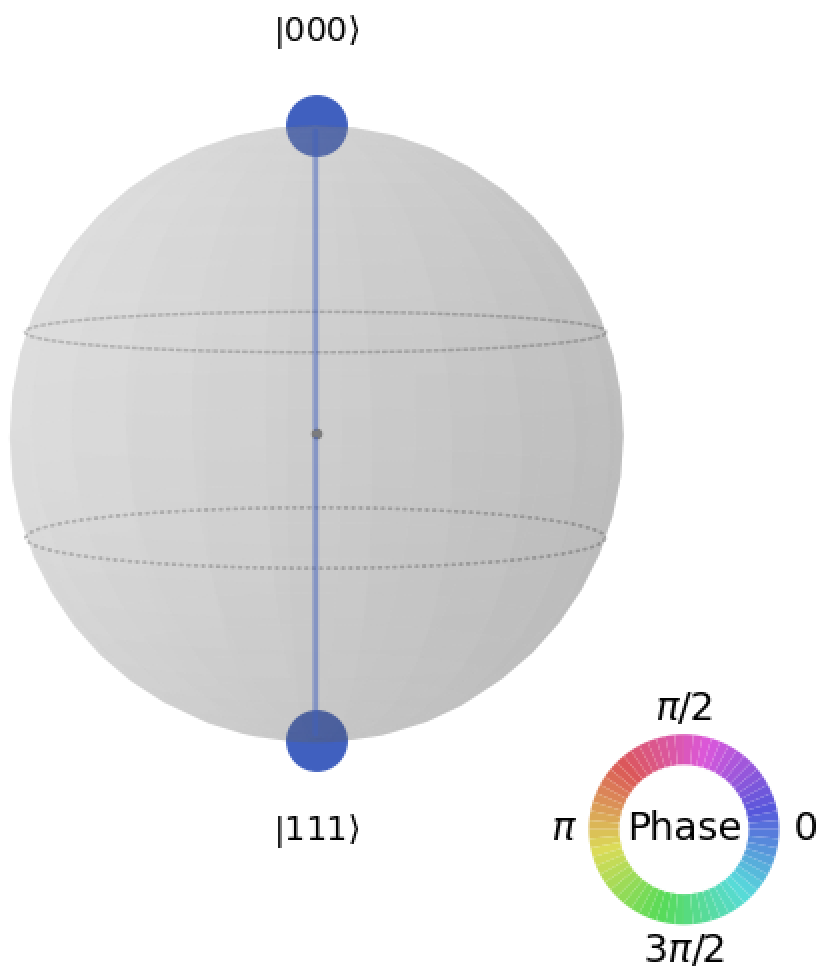
$$\begin{bmatrix} \frac{\sqrt{2}}{2} & 0 & 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{2}}{2} \end{bmatrix}$$

Q Sphere Visulization

- **Each quadrant is a qubit combination.**
- **Quadrants are associated with colors.**
- **Point position shows amplitude and phase.**
- **Larger points indicate higher amplitude.**
- **Angle shows phase, x-axis is 0 degrees.**
- **Q-sphere visualizes single and multi-qubit states.**
- **Helps in understanding and optimizing quantum algorithms.**

In [74]:
```
state.draw('qsphere')
```

Out[74]:



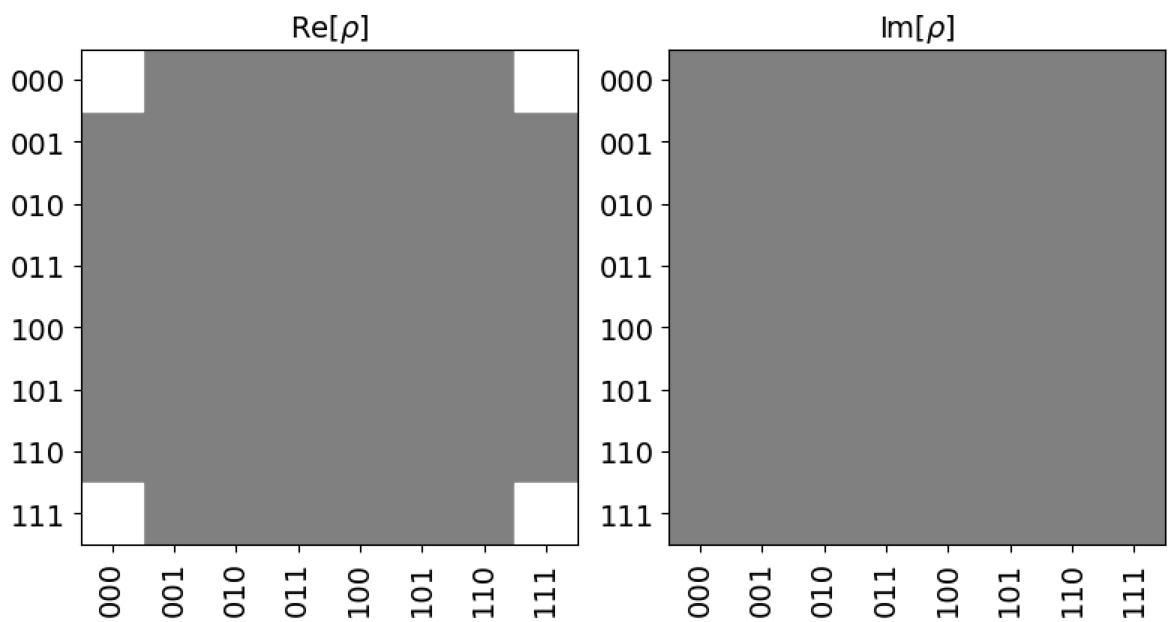
Hinton Visualization

- **Created by Geoff Hinton in the 1980s.**
- **Shows a matrix as a grid of squares.**
- **Square size represents the absolute value of the matrix element.**
- **Square color represents the sign of the element (black for negative, white for positive).**
- **Useful for visualizing weight matrices in neural networks.**
- **Can help to identify patterns and clusters of weights in the matrix.**

A hinton representing the real and imaginary components of the state density matrix p

In [69]:
```
state.draw('hinton')
```

Out[69]:



In [ ]:

Unitary backend

- **Calculates the unitary matrix that represents the quantum circuit.**
- **The unitary matrix describes how the quantum circuit transforms the input state into the output state.**
- **Useful for analyzing and optimizing small quantum circuits.**
- **Does not support measurements or classical control operations.**

In [37]:
```
backend = Aer.get_backend("unitary_simulator")
job= backend.run(cir)
result= job.result()

#showing the results
print(result.get_unitary(cir, decimals=3))
```

```
Operator([[ 0.707+0.j,  0.707-0.j,  0.   +0.j,  0.   +0.j,  0.   +0.j,
            0.   +0.j,  0.   +0.j,  0.   +0.j],
          [ 0.   +0.j,  0.   +0.j,  0.   +0.j,  0.   +0.j,  0.   +0.j,
            0.   +0.j,  0.707+0.j, -0.707+0.j],
          [ 0.   +0.j,  0.   +0.j,  0.707+0.j,  0.707-0.j,  0.   +0.j,
            0.   +0.j,  0.   +0.j,  0.   +0.j],
          [ 0.   +0.j,  0.   +0.j,  0.   +0.j,  0.   +0.j,  0.707+0.j,
           -0.707+0.j,  0.   +0.j,  0.   +0.j],
          [ 0.   +0.j,  0.   +0.j,  0.   +0.j,  0.   +0.j,  0.707+0.j,
            0.707-0.j,  0.   +0.j,  0.   +0.j],
          [ 0.   +0.j,  0.   +0.j,  0.707+0.j, -0.707+0.j,  0.   +0.j,
            0.   +0.j,  0.   +0.j,  0.   +0.j],
          [ 0.   +0.j,  0.   +0.j,  0.   +0.j,  0.   +0.j,  0.   +0.j,
            0.   +0.j,  0.707+0.j,  0.707-0.j],
          [ 0.707+0.j, -0.707+0.j,  0.   +0.j,  0.   +0.j,  0.   +0.j,
            0.   +0.j,  0.   +0.j,  0.   +0.j]],
         input_dims=(2, 2, 2), output_dims=(2, 2, 2))
```

In [ ]:

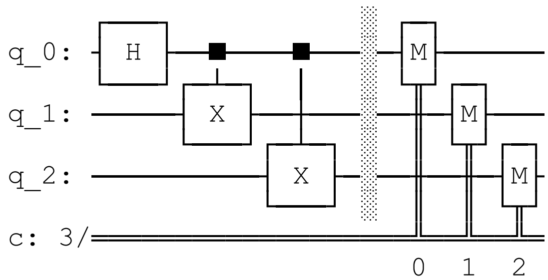
OpenQASM backend

```
- **Converts the quantum circuit into OpenQASM format, a low-level assembly language for quantum computers.**
- **Outputs a series of instructions in OpenQASM format that can be executed on a quantum device or simulator.**
- **Supports measurements and conditional operations.**
```

In [49]:
```
meas= QuantumCircuit(3,3)
meas.barrier(range(3))
#map the quantum measurment to the classical bits
meas.measure(range(3), range(3))

#The Qiskit circuit object supports composition using
# the compose method
# cir.add_register(meas.cregs[0])
qc= cir.compose(meas)
qc.draw()
```

Out[49]:



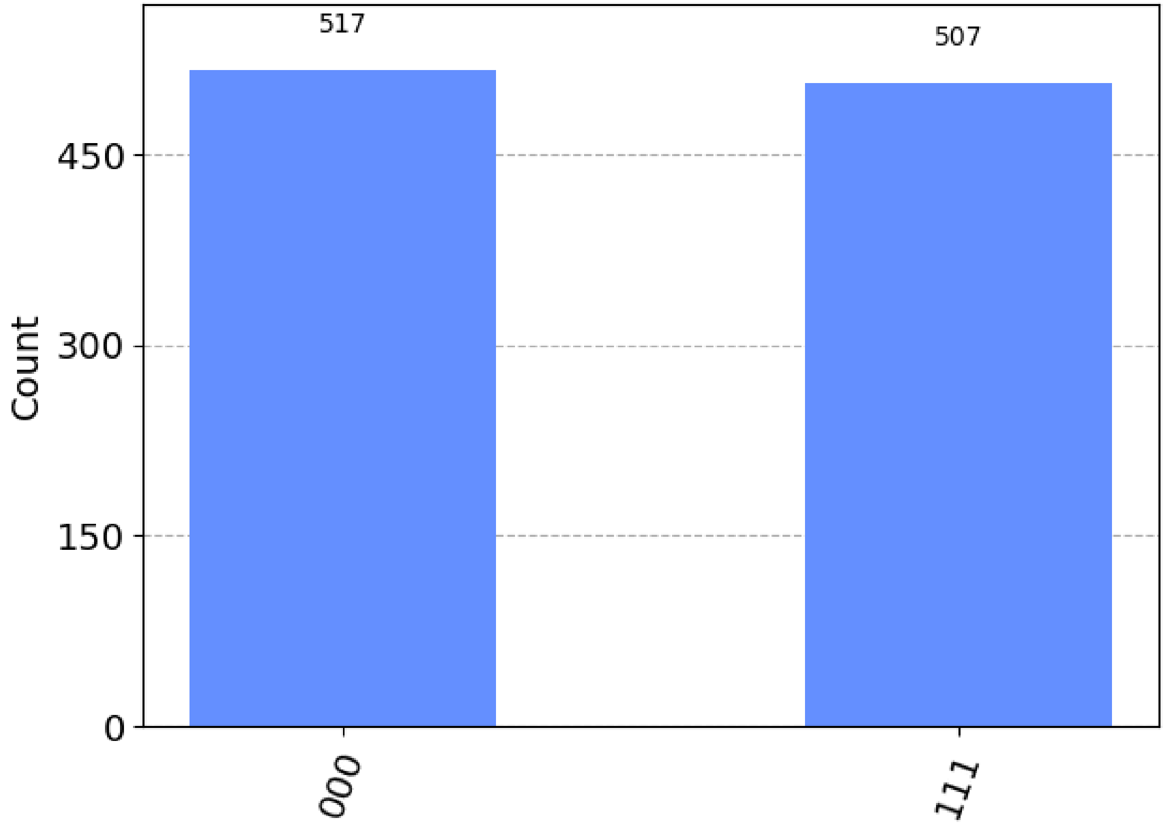
- **`   :`Simulation using Qasm**

In [75]:
```
backend_sim= Aer.get_backend('qasm_simulator')
job_sim= backend_sim.run(transpile(qc,backend_sim), shots=1024)
result_sim= job_sim.result()
counts= result_sim.get_counts(qc)
print(counts)
```

```
{'000': 528, '111': 496}
```

In [56]:
```
from qiskit.visualization import plot_histogram
plot_histogram(counts)
```

Out[56]:



In [58]:
```
import qiskit.tools.jupyter
%qiskit_version_table
```

Version Information

Qiskit Software	Version
qiskit-terra	0.23.3
qiskit-aer	0.11.2
qiskit-ignis	0.7.1
qiskit-ibmq-provider	0.20.0
qiskit	0.41.0
System information	
Python version	3.9.13
Python compiler	MSC v.1916 64 bit (AMD64)
Python build	main, Aug 25 2022 23:51:50
OS	Windows
CPUs	2
Memory (Gb)	7.872215270996094
Sun Apr 30 18:43:57 2023 Pakistan Standard Time	