Task I: Quantum Computing Part

1 implement a simple quantum operation with Cirq or Pennylane

- With 5 qubits
- Apply Hadamard operation on every qubit
- Apply CNOT operation on (0, 1), (1,2), (2,3), (3,4)
- SWAP (0, 4)
- Rotate X with pi/2 on any qubit
- Plot the circuit

2 Implement a second circuit with a framework of your choice:

- Apply a Hadmard gate to the first qubit
- rotate the second qubit by pi/3 around X
- Apply Hadamard gate to the third and fourth qubit
- Perform a swap test between the states of the first and second qubit |q1 q2>and the third and fourth qubit |q3 q4>

```
!pip install pennylane
```

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Collecting pennylane
  Downloading PennyLane-0.40.0-py3-none-any.whl.metadata (10 kB)
Requirement already satisfied: numpy<2.1 in
/usr/local/lib/python3.11/dist-packages (from pennylane) (2.0.2)
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Collecting rustworkx>=0.14.0 (from pennylane)
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Collecting pennylane-lightning>=0.40 (from pennylane)
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lightning, pennylane
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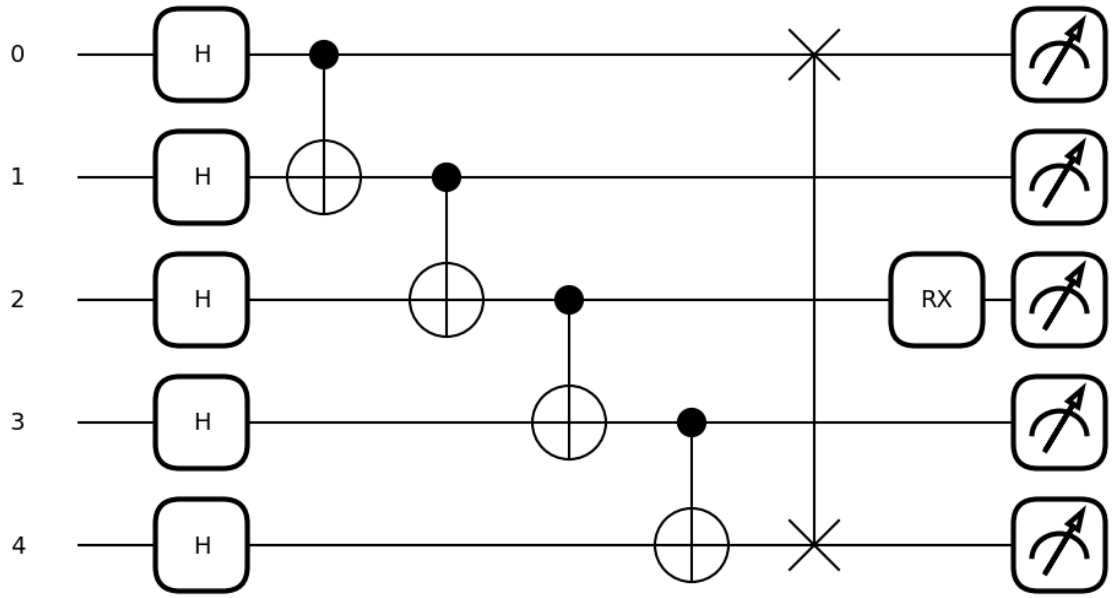
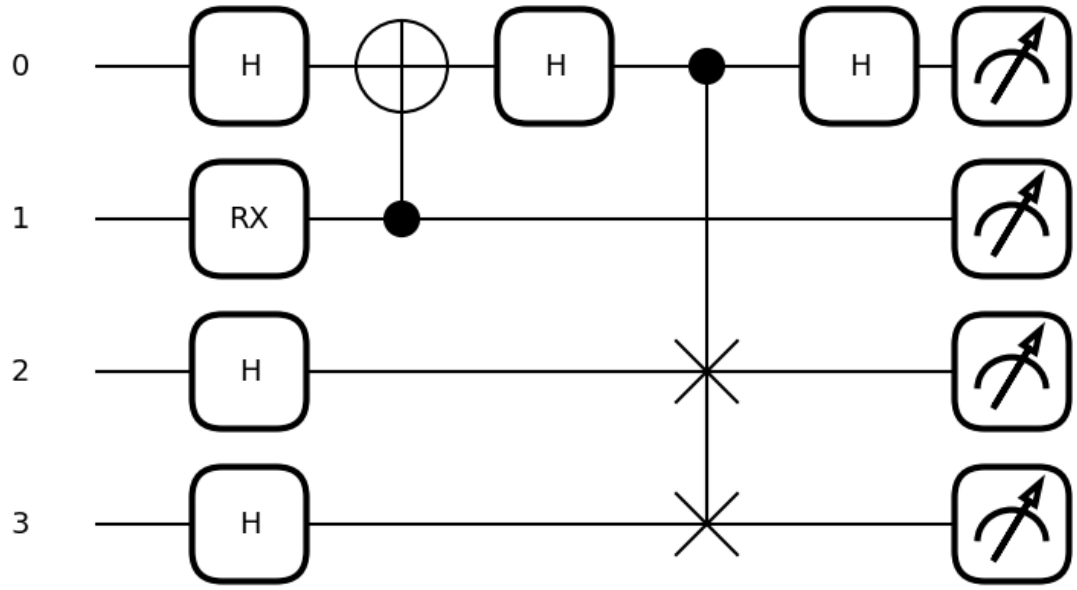
2.15.2 pennylane-0.40.0 pennylane-lightning-0.40.0 rustworkx-0.16.0
scipy-openblas32-0.3.29.0.0 tomlkit-0.13.2
```

```python
import pennylane as qml
from pennylane import numpy as np
import matplotlib.pyplot as plt

# Create a quantum device with 5 qubits
num_qubits = 5
dev = qml.device("default.qubit", wires=num_qubits)

### FIRST CIRCUIT IMPLEMENTATION ###
@qml.qnode(dev)
def quantum_circuit():
    # Apply Hadamard gate to all qubits
    for i in range(num_qubits):
        qml.Hadamard(wires=i)

    # Apply CNOT gates in sequence
    qml.CNOT(wires=[0, 1])
    qml.CNOT(wires=[1, 2])
    qml.CNOT(wires=[2, 3])
    qml.CNOT(wires=[3, 4])

    # Apply SWAP gate between qubit 0 and 4
    qml.SWAP(wires=[0, 4])

    # Rotate X by π/2 on qubit 2
    qml.RX(np.pi / 2, wires=2)

    return qml.state()

# Plot the first circuit
fig, ax = qml.draw_mpl(quantum_circuit)()
plt.show()
```




```
### SECOND CIRCUIT IMPLEMENTATION ###
@qml.qnode(dev)
def quantum_circuit_2():
    # Apply Hadamard gate to the first qubit
    qml.Hadamard(wires=0)

    # Rotate second qubit by π/3 around X
    qml.RX(np.pi / 3, wires=1)

    # Apply Hadamard gates to third and fourth qubits
    qml.Hadamard(wires=2)
    qml.Hadamard(wires=3)

    # SWAP test between (0,1) and (2,3)
    qml.CNOT(wires=[1, 0])  # First CNOT for entanglement
    qml.Hadamard(wires=0)    # Hadamard on control qubit
    qml.CSWAP(wires=[0, 2, 3])  # Controlled swap between (2,3)
    qml.Hadamard(wires=0)    # Final Hadamard to complete swap test

    return qml.state()

# Plot the second circuit
fig, ax = qml.draw_mpl(quantum_circuit_2)()
plt.show()
```


0
1
2
3
H
RX
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