TASK 2: Pauli Matrices and Eigenvalues/Eigenvectors

Aim: To analyze Pauli matrices through application on qubit states and eigenvalue decomposition.

Algorithm:

1. Define Pauli-X, Y, and Z matrices.
2. Apply these matrices to |0⟩ and |1⟩ states
3. Use linear algebra to compute eigenvalues and eigenvectors.
4. Print matrix properties.

```
import numpy as np
from numpy.linalg import eig

print("\n" + "="*50)
print("TASK 2: PAULI MATRICES AND EIGEN-ANALYSIS")
print("="*50)
# Define Pauli matrices
pauli_x = np.array([[0, 1], [1, 0]])
pauli_y = np.array([[0, -1j], [1j, 0]])
pauli_z = np.array([[1, 0], [0, -1]])
print("Pauli-X matrix:")
print(pauli_x)
print("\nPauli-Y matrix:")
print(pauli_y)
print("\nPauli-Z matrix:")
print(pauli_z)
# Apply to qubit states
qubit_0 = np.array([1, 0]) # |0⟩
qubit_1 = np.array([0, 1]) # |1⟩
print("\nApplying Pauli-X to |0⟩:", pauli_x @ qubit_0)
print("Applying Pauli-X to |1⟩:", pauli_x @ qubit_1)
# Compute eigenvalues and eigenvectors
def analyze_operator(matrix, name):
    eigenvals, eigenvecs = eig(matrix)
    print(f"\n{name} Eigenvalues:", eigenvals)
    print(f"{name} Eigenvectors:")
    for i, vec in enumerate(eigenvecs.T):
        print(f" λ={eigenvals[i]:.1f}: {vec}")

analyze_operator(pauli_x, "Pauli-X")
analyze_operator(pauli_y, "Pauli-Y")
analyze_operator(pauli_z, "Pauli-Z")
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Pauli-X matrix:
[[0 1]
 [1 0]]

Pauli-Y matrix:
[[ 0.+0.j -0.-1.j]
 [ 0.+1.j  0.+0.j]]

Pauli-Z matrix:
[[ 1  0]
 [ 0 -1]]

Applying Pauli-X to |0⟩: [0 1]
Applying Pauli-X to |1⟩: [1 0]

Pauli-X Eigenvalues: [ 1. -1.]
Pauli-X Eigenvectors:
 λ=1.0: [0.70710678 0.70710678]
 λ=-1.0: [-0.70710678  0.70710678]

Pauli-Y Eigenvalues: [ 1.+0.j -1.+0.j]
Pauli-Y Eigenvectors:
 λ=1.0+0.0j: [-0.        -0.70710678j  0.70710678+0.j        ]
 λ=-1.0+0.0j: [0.70710678+0.j         0.        -0.70710678j]

Pauli-Z Eigenvalues: [ 1. -1.]
Pauli-Z Eigenvectors:
 λ=1.0: [1. 0.]
 λ=-1.0: [0. 1.]
```

Result:

Pauli matrices were applied, and their eigenvalues and eigenvectors were correctly determined.