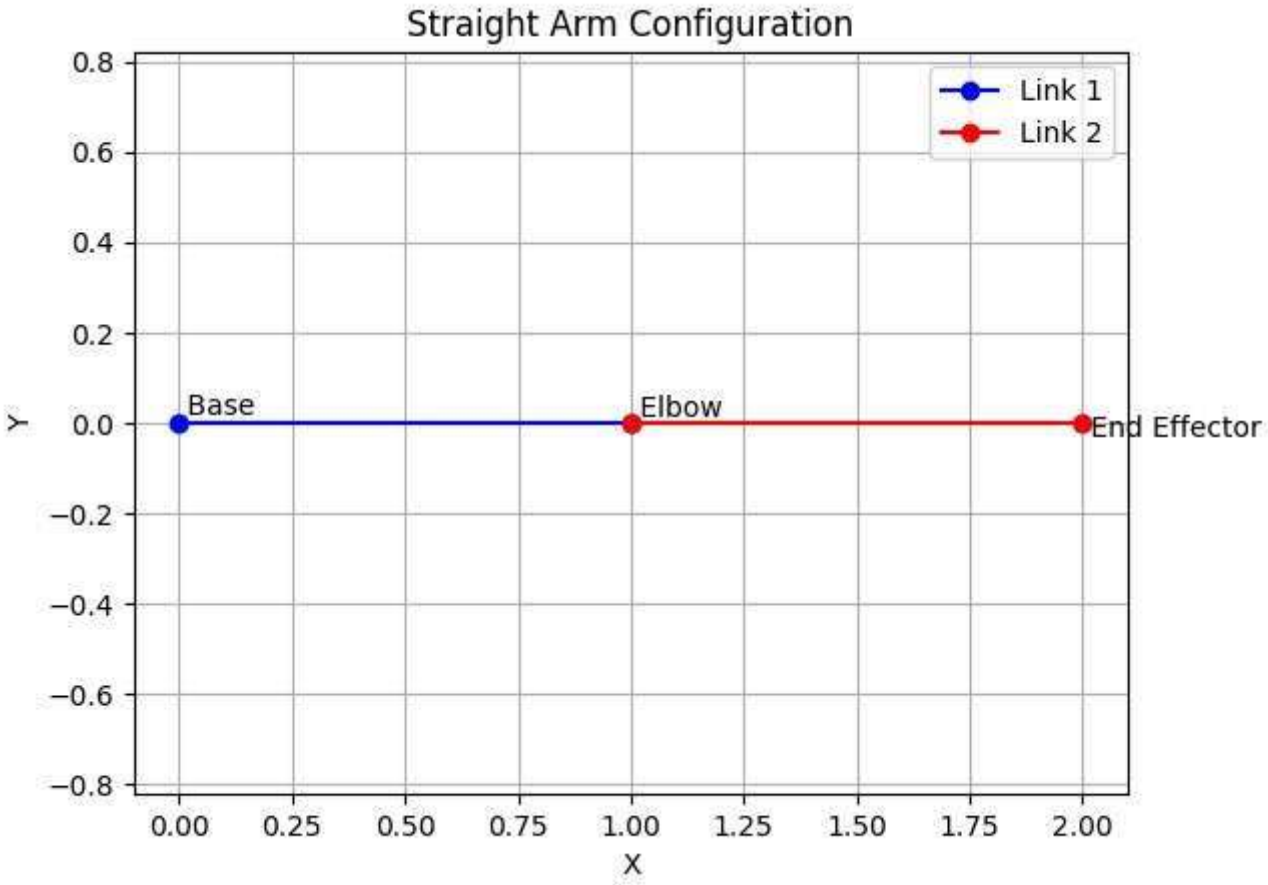
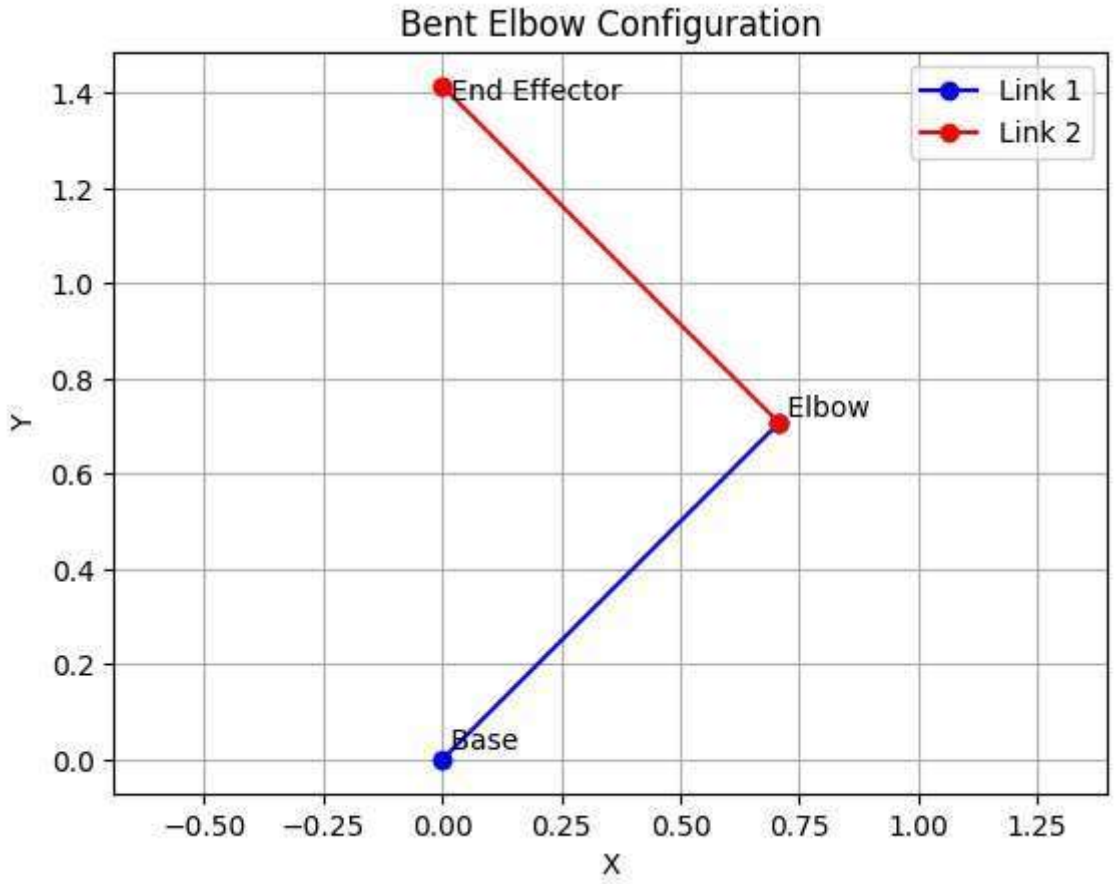
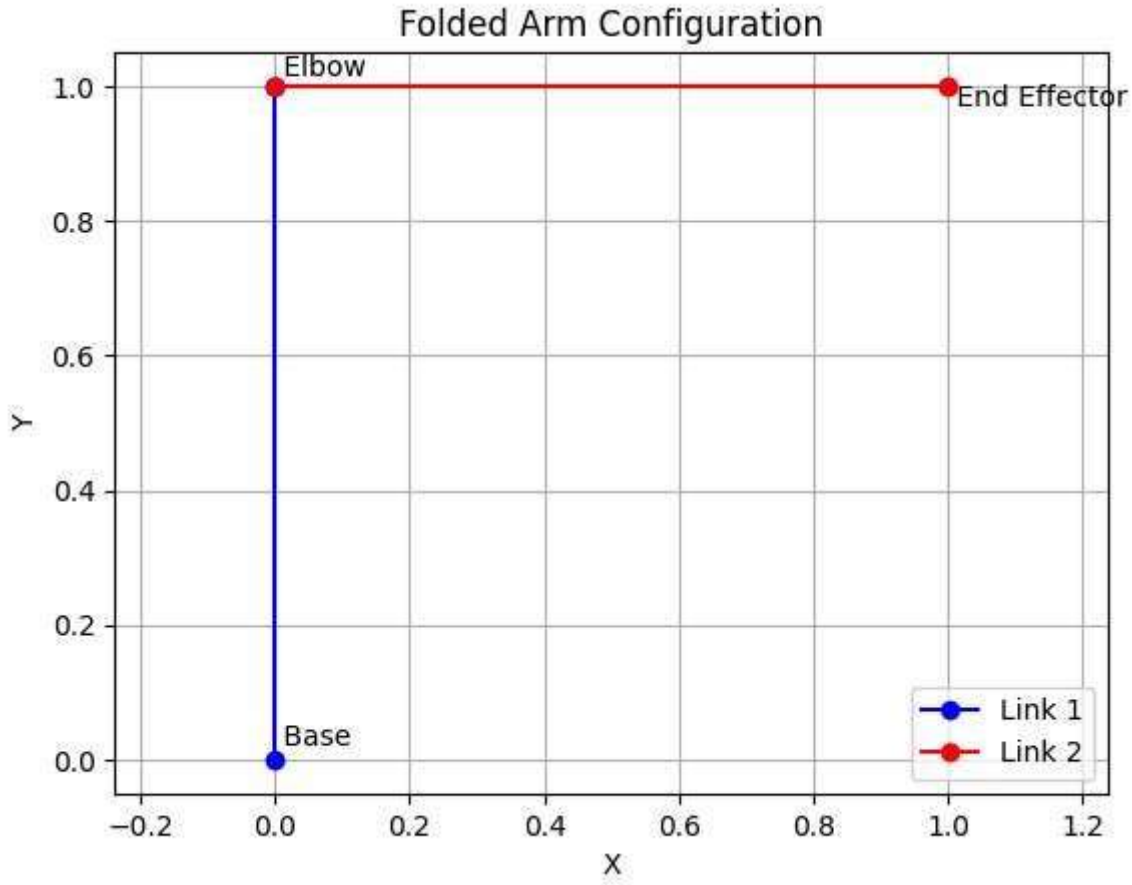
In [1]:

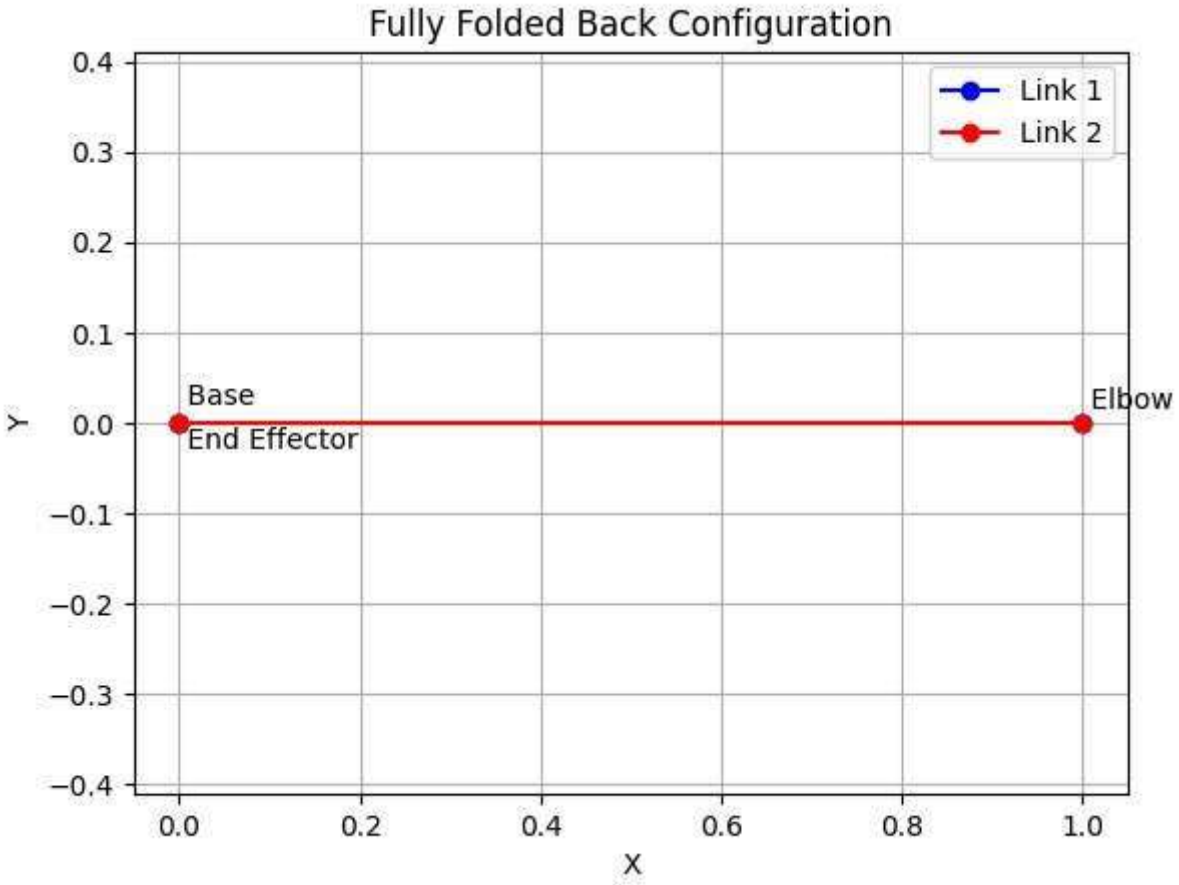
```python
import numpy as np
import matplotlib.pyplot as plt

# Link lengths
l1 = 1
l2 = 1

def compute_positions(q1, q2):
    # Base position
    x0, y0 = 0, 0

    # Elbow position
    x1 = l1 * np.cos(q1)
    y1 = l1 * np.sin(q1)

    # End-effector position
    x2 = x1 + l2 * np.cos(q1 + q2)
    y2 = y1 + l2 * np.sin(q1 + q2)

    return (x0, y0), (x1, y1), (x2, y2)

def Plot(q1, q2, title):
    base, elbow, ee = compute_positions(q1, q2)

    # X and Y coordinates
    x = [base[0], elbow[0], ee[0]]
    y = [base[1], elbow[1], ee[1]]

    plt.figure()
    # First Link
    plt.plot([base[0], elbow[0]], [base[1], elbow[1]],
             'o-', color='blue', label='Link 1')

    # Second Link
    plt.plot([elbow[0], ee[0]], [elbow[1], ee[1]],
             'o-', color='red', label='Link 2')

    plt.scatter(x, y)

    plt.text(base[0], base[1]+0.02, ' Base')
```

```
    plt.text(elbow[0], elbow[1]+0.015, 'Elbow')
    plt.text(ee[0], ee[1]-0.025, 'End Effector')


    plt.title(title)
    plt.xlabel("X")
    plt.ylabel("Y")
    plt.axis("equal")
    plt.legend()
    plt.grid()
    plt.show()
Plot(q1=0, q2=0, title="Straight Arm Configuration")
Plot(q1=np.pi/4, q2=np.pi/2, title="Bent Elbow Configuration")
Plot(q1=np.pi/2, q2=-np.pi/2, title="Folded Arm Configuration")
Plot(q1=0, q2=np.pi, title="Fully Folded Back Configuration")
```


Straight Arm Configuration
Link 1
Link 2
Base
Elbow
End Effector
0.8
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
−0.8
Y
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
X


Bent Elbow Configuration
End Effector
Elbow
Base
Link 1
Link 2
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Y
−0.50
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
X


Folded Arm Configuration
Elbow
End Effector
Base
Link 1
Link 2
X
Y
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
0.0
0.2
0.4
0.6
0.8
1.0
1.2


Fully Folded Back Configuration
Link 1
Link 2
Base
End Effector
Elbow
0.4
0.3
0.2
0.1
0.0
−0.1
−0.2
−0.3
−0.4
Y
0.0
0.2
0.4
0.6
0.8
1.0
X

Planar Robotic Arm

This document provides a short explanation describing how changes in joint angles q1 and q2 affect the position and workspace of a 2-link planar robotic arm.

Effect of Joint Angle q1

The joint angle q1 controls the orientation of the first link with respect to the x-axis. Changing q1 rotates the entire arm about the base. Both the elbow and the end-effector move together, while the shape of the arm remains unchanged. Hence, q1 affects the global orientation of the arm.

Effect of Joint Angle q2

The joint angle q2 controls the relative angle between the two links. When q2 = 0, the arm is fully extended and reaches maximum length. As q2 changes, the arm bends at the elbow, reducing the reach of the end-effector. Thus, q2 affects the shape and reach of the arm.

Workspace of the Robotic Arm

The maximum reach of the arm is equal to the sum of the two link lengths (2 units). By varying q1and q2, the end-effector sweeps a circular workspace. Some inner regions may be unreachable depending on the configuration.