ASSIGNMENT 1

Task 1

Base

$$(0,0)$$

Elbow Joint

$$X1 = l1 \ \cos(q1)$$

$$Y1 = l1 \ \sin(q1)$$

End Effector

$$X2 = X1 + l2 \cos(q1+q2)$$

$$Y2 = Y1 + l2 \sin(q1+q2)$$

Where $l1=l2=1$

Task 2

Python Script

```
import numpy as np

import matplotlib.pyplot as plt

# Link lengths

l1 = 1.0

l2 = 1.0

def forward_kinematics(q1, q2, l1=1.0, l2=1.0):
    """
    Returns elbow position (x1, y1) and end-effector position (x2, y2)
    """
    x1 = l1 * np.cos(q1)
    y1 = l1 * np.sin(q1)

    x2 = x1 + l2 * np.cos(q1 + q2)
    y2 = y1 + l2 * np.sin(q1 + q2)

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

# Three different configurations
```

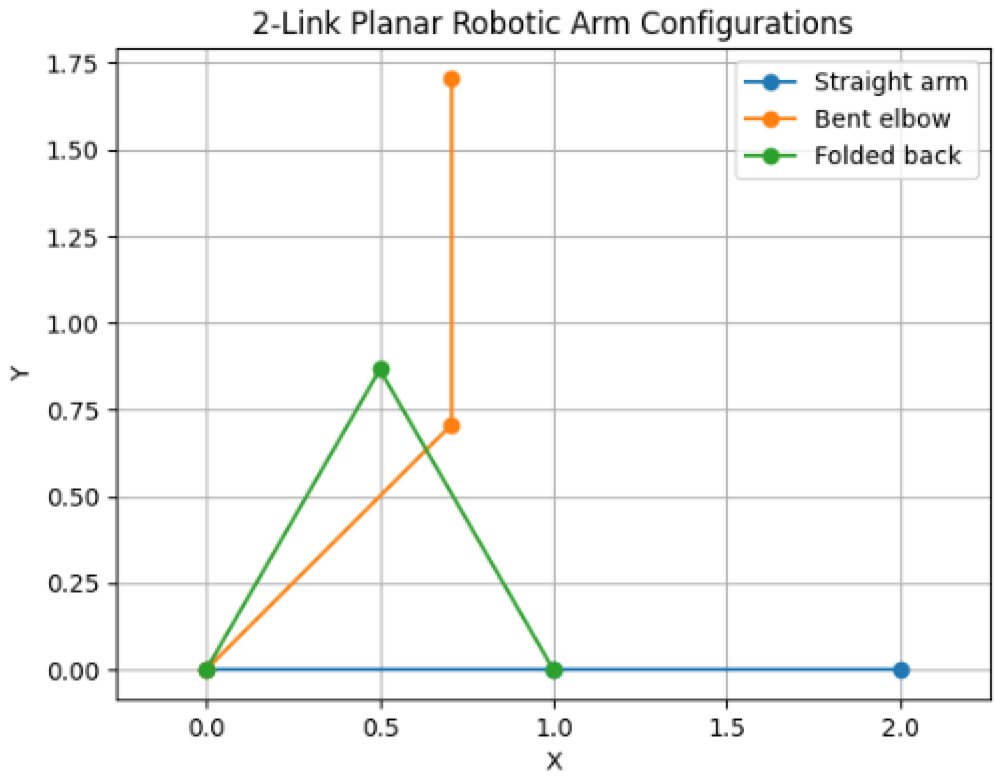
```python
configs = {
    "Straight arm": (0.0, 0.0),
    "Bent elbow": (np.pi/4, np.pi/4),
    "Folded back": (np.pi/3, -2*np.pi/3),
}

plt.figure()

for name, (q1, q2) in configs.items():
    elbow, ee = forward_kinematics(q1, q2)

    # Plot links
    x_vals = [0, elbow[0], ee[0]]
    y_vals = [0, elbow[1], ee[1]]
    plt.plot(x_vals, y_vals, marker='o', label=name)

plt.axis("equal")
plt.xlabel("X")
plt.ylabel("Y")
plt.title("2-Link Planar Robotic Arm Configurations")
plt.legend()
plt.grid(True)
plt.show()
```


2-Link Planar Robotic Arm Configurations
Straight arm
Bent elbow
Folded back
Y
X
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
0.0
0.5
1.0
1.5
2.0

Explanation: Effect of q_1 and q_2

Effect of q_1

Rotates the **entire arm** about the base.

Changes the global orientation of both links.

Does **not** change the relative shape of the arm.

Effect of q_2

Controls the **bend at the elbow**.

Changes the distance of the end-effector from the base.

Large negative or positive values can fold the arm back toward the base

Workspace Insight

Maximum reach:

Rmax=l1+l2=2

Minimum reach (fully folded):

Rmin=|l1−l2|=0

The reachable workspace is a **circle of radius 2** centered at the origin.