Week 2 Assignments. Deadline is at midnight 17th March 2025

Question 1: Simulating a 1D Random Walk with Step Bias

A particle moves along a **one-dimensional line (1D)**. At each time step, it can either move:

- **+1 step** to the right with probability p, or
- **-1 step** to the left with probability $1-p$

Suppose $p=0.85$ (i.e., a bias to the right).

Instructions:

1. **Write a Python program** to simulate a **1D random walk** with **1000 steps** where:
    - The starting position is 0.
    - Each step has a probability of $p=0.85$ to move right and $1-p=0.15$ to move left.
2. Plot the **position vs time** graph (time on x-axis, position on y-axis).
3. Run the simulation **five times** and overlay all five random walks in the same graph.
4. **Calculate and interpret**:
    - The final position of the particle after 1000 steps.
    - The mean and standard deviation of the final position across five simulations.

Question 2: Comparing 1D Random Walks with and without Drift

Suppose two particles perform **1D random walks** starting from position 0:

- **Particle A:** Moves with a drift, i.e., $p=0.7$ (70% chance to move right).
- **Particle B:** Moves without drift, i.e., $p=0.5$(equal probability both sides).

Instructions:

1. **Write a Python program** to simulate **1000 steps** for each particle.
2. Plot both random walks on the **same graph** with:
    - **Time on the x-axis.**
    - **Position on the y-axis.**
    - Different colors for each particle.
3. **Calculate and display:**
    - The mean and standard deviation of the final position after 1000 steps.
4. **Interpret your answer**

Question 3: Simulating a 2D Random Walk (Unbiased)

A mosquito trapped in a square grid moves randomly:

- **Up, Down, Left, or Right** with **equal probability (25%)** in each direction.
- The mosquito starts at coordinate (0,0).

Instructions:

1. **Write a Python program** to simulate a **2D random walk** for 500 steps.
2. Plot the path of the mosquito (X vs Y) using a scatter plot or line plot.
3. **Calculate and display:**
    - The final position after 500 steps.
    - The total distance from the origin after 500 steps.
4. **Run the simulation 10 times** and calculate:
    - The average distance from the origin after 500 steps.
    - The standard deviation of the distance.
5. **Interpret your answer**

Question 4: Comparing 2D Random Walks with Bias vs No Bias

A person walks randomly in a 2D grid but with a **slight bias towards the East (right)**.

- In each step:
    - **Move East:** 40% probability
    - **Move West:** 20% probability
    - **Move North:** 20% probability
    - **Move South:** 20% probability

The person starts at (0,0).

Instructions:

1. **Write a Python program** to simulate:
    - **500 steps** for the biased random walk.
    - **500 steps** for an unbiased random walk (equal probability).
2. **Plot both paths** on the same graph with:
    - Different colors for each walk.
    - Scatter plot showing the final position.
3. **Calculate and display:**
    - The final position after 500 steps.
    - The total distance from the origin for both walks.
4. **Run the simulation 10 times** and compute:
    - The average distance from the origin for both biased and unbiased walks.
    - The standard deviation of the distance.
5. **Interpretation:**
    - Why does the biased random walk drift to the east?
    - How does drift affect the standard deviation of the final position?
    - What real-world phenomena could this simulation represent (e.g., wind drift, ocean currents)?