Assignment 15: Topological Plane Sweep Visualization

Problem Statement:

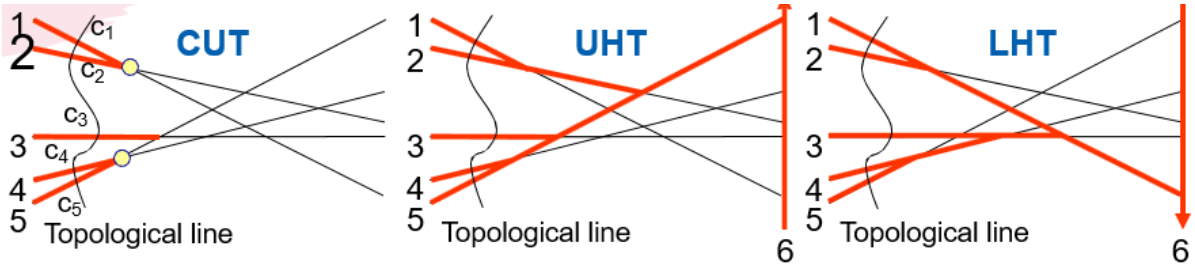
You are required to write a Python program that performs the **Topological Plane Sweep** algorithm on a set of **N** randomly generated 2D lines. Your program should:

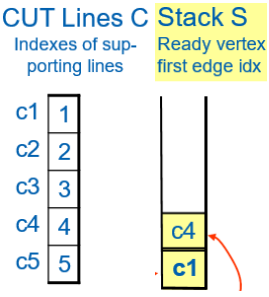
1. **Generate a set of N non-parallel and simple (No ≥3 lines can intersect at one point) random lines** in 2D using randomly selected slopes and y-intercepts.
2. **Construct the arrangement** by computing all pairwise intersection points.
3. **Initialize the topological cut** at the far-left point of the arrangement and determine the top-to-bottom order of the lines at this x-coordinate (Basically sort them by their slopes).
4. **Iteratively perform the elementary steps** of the topological plane sweep:
    - Identify and maintain the **Upper Horizon Tree (UHT)** and **Lower Horizon Tree (LHT)** at each step.
    - Use a **stack** to manage the ready vertices and apply all necessary pairwise swaps in the cut during elementary steps.
5. **Visualize the sweep** at every step:
    - Plot the lines and their intersections.
    - Show the current cut position and label the line order.
    - Display UHT and LHT.
    - Display the **stack contents** and current **cut ordering**.

Input: A single integer `N` representing the number of 2D lines to generate.

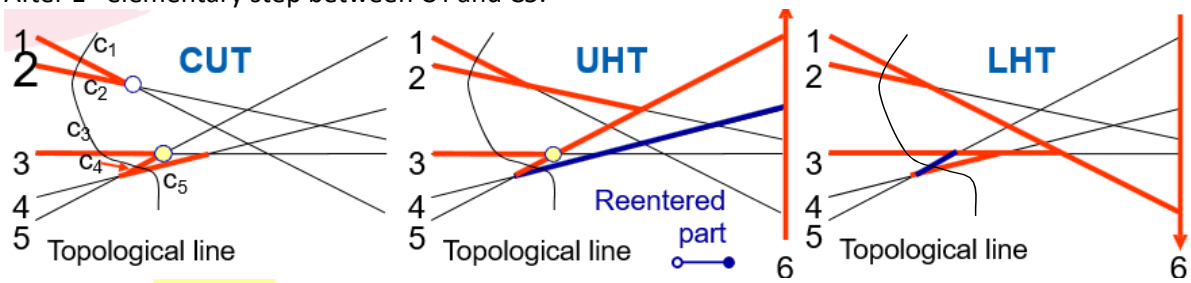
Example: For input N=5, the output for each step should looks like the following:

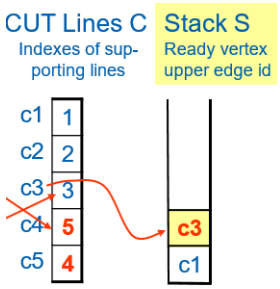
1) Initial Arrangement and corresponding UHT and LHT, Stack Contents, Cut Orderings



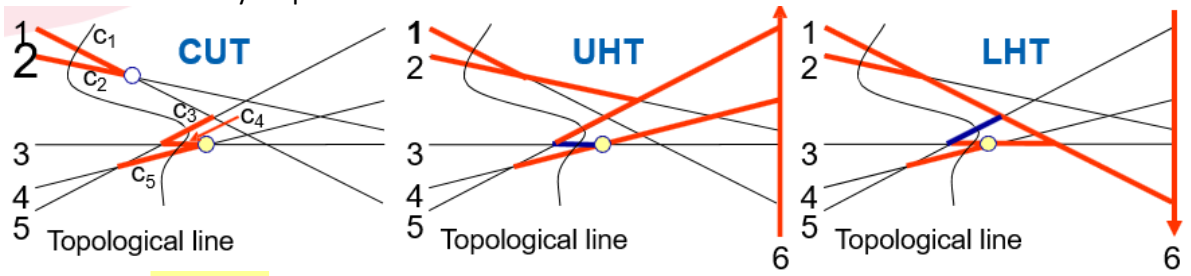


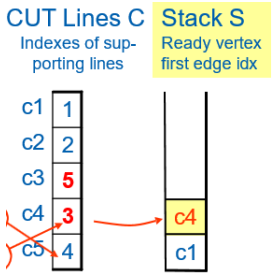
2) After 1st elementary step between C4 and C5.





3) After 2nd elementary step between C3 and C4.





In this way, you should do all the elementary steps until you reach the rightmost Cuts.