Batyr I and Tima the Great

- Author — Batyr Sardarbekov;
- Developers — Dinmukhamed Tursynbay, Aibar Kuanyshbay, Batyr Sardarbekov.

Subtask 1 ($m = 0$) — 5 points

In this subtasks, it is simple to see that you either move in circle clockwise or anticlockwise so answer is minimum between $|x_i - y_i|$ or $L - |x_i - y_i|$.

Subtask 2 $L, m, q \leq 10^2$ — 8 points

Let's build graph for each query, then Batyr's roads has weight 1 and Tima's roads has weight 0. And run shortest path algorithms to find answer.

Subtask 3 $L, m, q \leq 10^3$ — 11 points

Let's build graph before processing queries like in second subtask, and then run BFS or Dijkstra for each pair in query to find answer.

Subtask 4 $m, q \leq 10^3$ — 10 points

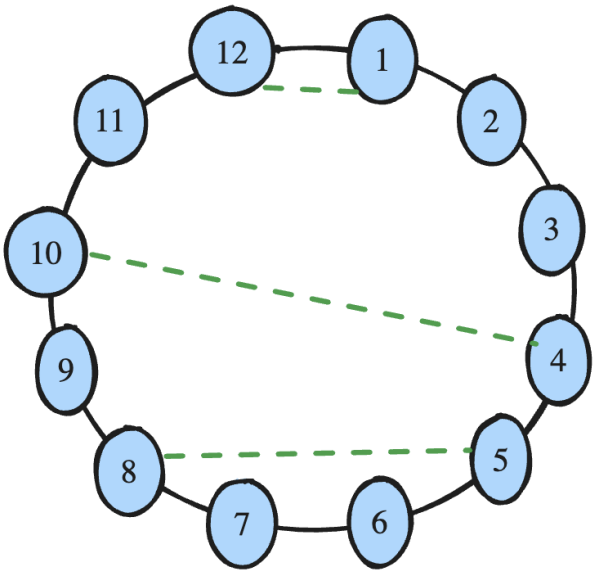
Notice that in previous subtask, you can build graph with nodes which appear only in one of queries or in Tima's edges. so we have $2(m+q)$ nodes on which we can build graph, and solve similar to third subtask.

Subtask 5 $b_i < a_{i+1}$ — 12 points

Consider Tima's roads as segments. Observe that no two segments intersect, and none of them completely cover each other. When moving from x to y, the distance covered is equal to $y - x -$ sum, where sum is the total length $\sum(b_i - a_i)$ of segments that lie entirely within the range $[x, y]$.

Subtask 6 $a_i < a_{i+1}, b_{i+1} < b_i$ — 14 points

Consider Tima's roads as segments. Note that while no segment intersects, each of them covers the other, implying a hierarchy among them. Add segment $[0, L]$ and then build a tree graph on this set of segments. For each segment, identify the shortest segment covering it, which becomes its parent in the tree. Additionally, in this tree, each point is part of the shortest segment covering it. Achieve this using a scanline: sort segments by their left side and maintain a stack of segments to easily find the parent. The weight of each edge is the distance between the closest points of the parent and son segments. To better understand how to handle queries, consider the given graph below, where $L = 12$, and Tima's roads are represented by the green lines.



As example to understand, let's use 3 and 9. so 3 will be linked to segment $[1, 12]$. while 9 to $[4, 10]$ in our tree. So in this case it is optimal to move from 3 to segment $[4, 10]$ and then from 10 to 9, so answer is 2. And let's consider another query 4, 9 in this case it is trivial we move from 4 to 10 and then 9, so answer is 1. in first example we moved to segment $[4, 10]$ which is son lca ($[1, 12]$) of segments $[4, 10]$ and $[1, 12]$, and in second it is going to lca ($[4, 10]$). It can be shown, that it's optimal to either go from both points to lca, or going to son of lca and then between them to each other. Time complexity is $O(nlogn)$.

Subtask 7 $|x_i - y_i| = 1$ $(1 \leq i \leq q)$ — 18 points

In this version of problem, if x_i and y_i are connected by Tima's roads, the answer is 0; otherwise, it is 1. To determine if they are connected in that way, let's merge two of Tima's roads if they intersect each other but do not entirely cover one another. First, connect roads by their endpoints. When considering roads a and b, we need to identify all the roads that intersect them. For instance, if $a < b$, we deem some endpoints of road u as valid if u lies between a and b, and the rightmost endpoint from u is greater than or equal to b. Conversely, if $a > b$, for endpoints u in between, we need to check if the leftmost endpoint from u is less than or equal to b. We can find such endpoints using a segment tree and use a disjoint-set union (dsu) structure to connect them as components. This process can be accomplished in $O(n \log n)$ time.

Subtask 8 No additional constraints — 22 points

After building components same to subtask 7, we are left we almost same problem as subtask 6 but you also need to consider that compare to subtask 6 components are set of points rather than segment.