2022 Canadian Computing Olympiad
Day 1, Problem 1
Alternating Heights

Time Limit: 2 seconds

Problem Description

Troy is planning to take a group photo of the students at CCO and has asked you for help.

There are K students, numbered from 1 to K. Troy has forgotten the students' heights, but remembers that no two students have the same height.

Troy has prepared a sequence $A_1, A_2, \ldots, A_N$ representing the order of students in the group photo, from left to right. It is possible for a student to appear multiple times in A. You aren't sure how this group photo would be taken, but you're unwilling to assume that Troy made a mistake.

Troy will ask you Q queries of the form x y, which is a compact way of asking "Given the sequence of students $A_x, A_{x+1}, \ldots, A_y$, can their heights form an alternating sequence?" More precisely, we denote the height of the ith student as $h[i]$. If there exists an assignment of heights $h[1], h[2], \ldots, h[K]$ such that $h[A_x] > h[A_{x+1}] < h[A_{x+2}] > h[A_{x+3}] < \ldots h[A_y]$, answer YES; otherwise answer NO.

Note that each of the Q queries will be independent: that is, the assignment of heights for query i is independent of the assignment of heights for query j so long as $i \neq j$.

Input Specification

The first line of input will contain three space-separated integers N, K, and Q.

The second line of input will contain the array $A_1, A_2, \ldots, A_N$ $(1 \leq A_i \leq K)$.

The next Q lines will each contain a query of the form of two space-separated integers x and y $(1 \leq x < y \leq N)$.

Marks Awarded	**Bounds on N**	**Bounds on K**	**Bounds on Q**
4 marks	$2 \leq N \leq 3000$	$K = 2$	$1 \leq Q \leq 10^6$
6 marks	$2 \leq N \leq 500$	$2 \leq K \leq \min(N, 5)$	$1 \leq Q \leq 10^6$
7 marks	$2 \leq N \leq 3000$	$2 \leq K \leq N$	$1 \leq Q \leq 2000$
8 marks	$2 \leq N \leq 3000$	$2 \leq K \leq N$	$1 \leq Q \leq 10^6$

Output Specification

Output Q lines. On the i^{th} line, output the answer to Troy's ith query. Note that the answer will be either `YES` or `NO`.

Sample Input

```
6 3 3
1 1 2 3 1 2
1 2
2 5
2 6
```

Output for Sample Input

```
NO
YES
NO
```

Explanation of Output for Sample Input

For the first query, we will never have $h[1] > h[1]$ so the answer is no.

For the second query, one solution to $h[1] > h[2] < h[3] > h[1]$ is $h[1] = 160\text{cm}$, $h[2] = 140\text{cm}$, $h[3] = 180\text{cm}$. Another solution could be $h[1] = 1.55\text{m}$, $h[2] = 1.473\text{m}$, $h[3] = 1.81\text{m}$.

For the third query, we cannot have both $h[1] > h[2]$ and $h[1] < h[2]$.

2022 Canadian Computing Olympiad
Day 1, Problem 2
Rainy Markets

Time Limit: 1.5 seconds

Problem Description

There are N covered bus shelters, labelled $1, \ldots, N$. The ith bus shelter can fit B_i people inside.

For each $i \in \{1, \ldots, N-1\}$, there is a sidewalk connecting bus shelter i to bus shelter $i+1$, with an open-air market in the middle. The ith market has U_i umbrellas for sale, each costing \$1.

Right now, the ith market has P_i people inside, and every person is in a market so all the bus shelters are empty.

Suddenly, it starts raining, and everyone at market i has to decide between three possibilities:

- to go to bus shelter i;
- to go to bus shelter $i+1$; or
- to stay and buy an umbrella.

If a person is unable to find a place in a bus shelter or buy an umbrella, they will get wet.

If everyone coordinates optimally, can they all stay dry? If so, what is the least amount of money they need to spend, and which bus shelter should each person move to?

Input Specification

The first line of input contains N.

The second line of input contains N space-separated integers B_i $(1 \leq i \leq N)$, the capacity of bus shelter i.

The third line of input contains $N-1$ space-separated integers P_i $(1 \leq i \leq N-1)$, the number of people at market i.

The fourth line of input contains $N-1$ space-separated integers U_i $(1 \leq i \leq N-1)$, the number of umbrellas for sale at market i.

Marks Awarded	Number of bus shelters	Maximum people/bus shelters	Maximum people/market	Maximum umbrellas/market
5 marks	$2 \leq N \leq 10^6$	$0 \leq B_i \leq 2 \cdot 10^9$	$0 \leq P_i \leq 10^9$	$U_i = 0$
5 marks	$2 \leq N \leq 2000$	$0 \leq B_i \leq 400$	$0 \leq P_i \leq 200$	$0 \leq U_i \leq 200$
6 marks	$2 \leq N \leq 4000$	$0 \leq B_i \leq 4000$	$0 \leq P_i \leq 2000$	$0 \leq U_i \leq 2000$
9 marks	$2 \leq N \leq 10^6$	$0 \leq B_i \leq 2 \cdot 10^9$	$0 \leq P_i \leq 10^9$	$0 \leq U_i \leq 10^9$

Output Specification
If every person can stay dry either under an umbrella or at a bus shelter, the output will be $N + 1$ lines:

- the first line will contain the word `YES`.
- the second line will contain the least amount of money necessary to spend on umbrellas
- the next $N - 1$ lines will each contain three space-separated integers:
  - the number of people at market i moving to bus shelter i
  - the number of people at market i buying an umbrella
  - the number of people at market i moving to bus shelter $i + 1$

  where $1 \leq i \leq N - 1$.

If not every person can stay dry, the output will be one line containing the word `NO`.

If there are multiple possible correct outputs, any correct output will be accepted.

Sample Input 1
```
3
10 15 10
20 20
0 0
```

Output for Sample Input 1
```
NO
```

Explanation of Output for Sample Input 1
There are 35 spots available at bus shelters and no umbrellas available, but there are 40 people in the markets.

Sample Input 2
```
3
```

```
10 15 10
20 20
0 11
```

Possible Output for Sample Input 2

```
YES
5
10 0 10
5 5 10
```

Explanation of Output for Sample Input 2

Looking at market 1, 10 people will go to bus shelter 1, no one will buy an umbrella, and 10 people will go to bus shelter 2.

Looking at market 2, 5 people will go to bus shelter 2, 5 people will stay and buy an umbrella, and 10 people will move to bus shelter 3.

In total, 5 umbrellas were purchased, which costs $5.

2022 Canadian Computing Olympiad
Day 1, Problem 3
Double Attendance

Time Limit: 3 seconds

Problem Description

Due to a rather ambitious school schedule, two of your classes are about to be held starting at exactly the same time, in two different classrooms! You can only be in one place at a time, so the best you can hope for is catching the important bits of both, even if that means sneaking back and forth between the two.

The two classrooms are numbered 1 and 2. In classroom i, the teacher will show N_i different slides during the class, with the jth slide shown throughout the *exclusive* time interval $(A_{i,j}, B_{i,j})$ $(0 \leq A_{i,j} < B_{i,j})$ where $A_{i,j}$ and $B_{i,j}$ are times elapsed since the start of class measured in seconds. In both classes, there does not exist a point in time at which multiple slides are simultaneously being shown. For example, a class may have slides spanning the pair of intervals $(1, 2)$ and $(5, 6)$, or the pair $(10, 20)$ and $(20, 30)$, but *not* the pair $(10, 20)$ and $(19, 30)$.

You begin the day in classroom 1 with both classes starting at time 0. Following that, at any point in time (not necessarily after an integral number of seconds), you may move from your current classroom to the other one in K seconds. You consider yourself to have seen a slide if you spend a positive amount of time in its classroom strictly within the time interval during which it's being shown. When moving between the two classrooms, you're not considered to be inside either of them for K seconds, and are thus unable to see any slides.

For example, if classroom 1 has a slide being shown for the time interval $(10, 20)$, classroom 2 has a slide being shown for the time interval $(15, 25)$, and $K = 8$, then you'll get to see both slides if you move from classroom 1 to classroom 2 at time 11.5 seconds (arriving at time 19.5 seconds). On the other hand, if you leave classroom 1 at time 17 seconds (arriving at time 25 seconds), then you'll enter classroom 2 just after its slide stops being shown and will therefore miss it.

What's the maximum number of distinct slides which you can see at least once?

Input Specification

The first line contains three space-separated integers, N_1, N_2, and K.

The next N_1 lines each contain two space-separated integers $A_{1,i}$ and $B_{1,i}$ $(1 \leq i \leq N_1)$.

The next N_2 lines each contain two space-separated integers, $A_{2,i}$ and $B_{2,i}$ $(1 \leq i \leq N_2)$.

Marks Awarded	Bounds on N_i	Bounds on $A_{i,j}$ and $B_{i,j}$	Bounds on K
5 marks	$1 \leq N_i \leq 10$	$0 \leq A_{i,j} < B_{i,j} \leq 2000$	$1 \leq K \leq 10^9$
10 marks	$1 \leq N_i \leq 2000$	$0 \leq A_{i,j} < B_{i,j} \leq 2000$	$1 \leq K \leq 10^9$
6 marks	$1 \leq N_i \leq 2000$	$0 \leq A_{i,j} < B_{i,j} \leq 10^9$ $B_{i,j} - A_{i,j} \leq 2K$	$1 \leq K \leq 10^9$
4 marks	$1 \leq N_i \leq 300\,000$	$0 \leq A_{i,j} < B_{i,j} \leq 10^9$	$1 \leq K \leq 10^9$

Output Specification

Output one integer which is the maximum number of distinct slides which you can see.

Sample Input 1

```
3 1 8
10 20
100 101
20 21
15 25
```

Output for Sample Input 1

```
3
```

Explanation of Output for Sample Input 1

One possible optimal strategy is to remain in classroom 1 until time 11.5, then move to classroom 2 (arriving at time 19.5), remain there until time 19.6, and finally return to classroom 1 (arriving at time 27.6). In the process, you'll see all but the 3rd slide. It's impossible for you to see all 4 slides.

Sample Input 2

```
1 5 3
1 100
1 2
2 3
3 4
4 5
5 6
```

Output for Sample Input 2

```
4
```

Explanation of Output for Sample Input 2

Even if you begin moving to classroom 2 immediately at the start of the classes, (e.g., at time 0.0001), you'll miss the first 2 slides shown there. As such, it is possible to see a total of at most four slides.