Topic 5: Tree: Review, LCA, HLD

Handout

CS 41100 - CP3 Competitive Programming III (Spring 2024)

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Date: February 17, 2025

Sample Problem: Query on A Tree
Link: `https://vjudge.net/problem/HDU-6191`

Sample Problem: Maze Designer
Link: `https://vjudge.net.cn/problem/%E8%AE%A1%E8%92%9C%E5%AE%A2-31462`

Sample Problem: Very Important Edge
Link: `https://vjudge.net.cn/problem/Kattis-veryimportantedge`

Query on A Tree

Monkey A lives on a tree, he always plays on this tree.

One day, monkey A learned about one of the bit-operations, xor. He was keen on this interesting operation and wanted to practise it at once.

Monkey A gave a value to each node on the tree. And he was curious about a problem.

The problem is how large the xor result of number x and one node value of label y can be, when giving you a non-negative integer x and a node label u indicates that node y is in the subtree whose root is u (y can be equal to u).

Can you help him?

Input

There are no more than 6 test cases.

For each test case there are two positive integers n and q, indicate that the tree has n nodes and you need to answer q queries.

Then two lines follow.

The first line contains n non-negative integers $V_1, V_2, \cdots, V_n$, indicating the value of node i.

The second line contains $n-1$ non-negative integers $F_1, F_2, \cdots, F_{n-1}$, F_i means the father of node $i+1$.

And then q lines follow.

In the i-th line, there are two integers u and x, indicating that the node you pick should be in the subtree of u, and x has been described in the problem.

$2 \le n, q \le 10^5$

$0 \le V_i \le 10^9$

$1 \le F_i \le n$, the root of the tree is node 1.

$1 \le u \le n, 0 \le x \le 10^9$

Output

For each query, just print an integer in a line indicating the largest result.

Examples

Input

```
2 2
1 2
1
1 3
2 1
```

Output

```
2
3
```

Source

2017 ACM/ICPC Guangxi Regional

Maze Designer

After the long vacation, the maze designer master has to do his job. A tour company gives him a map which is a rectangle. The map consists of $N \times M$ little squares. That is to say, the height of the rectangle is N and the width of the rectangle is M. The master knows exactly how the maze is going to be used. The tour company will put a couple in two different squares in the maze and make them seek each other. Of course, the master will not make them find each other easily. The only thing the master does is building some walls between some little squares. He knows that in that way, wherever the couple is put, there is only one path between them. It is not a difficult thing for him, but he is a considerate man. He also knows that the cost of building every wall between two adjacent squares is different (Nobody knows the reason). As a result, he designs the maze to make the tour company spend the least money to build it.

Now, here's your part. The tour company knows you're the apprentice of the master, so they give you a task. You're given Q questions which contain the information of where the couple will be put. You need to figure out the length of the shortest path between them.

However, the master doesn't tell you how he designs the maze, but he believes that you, the best student of himself, know the way. So he goes on vacation again.

Input

The first line of the input contains two integers N and M ($1 \le N, M \le 500$), giving the number of rows and columns of the maze.

The next $N \times M$ lines of the input give the information of every little square in the maze, and their coordinates are in order of $(1,1)$, $(1,2)$, $\cdots$, $(1,M)$, $(2,1)$, $(2,2)$, $\cdots$, $(2,M)$, $\cdots$, (N,M).

Each line contains two characters D and R and two integers a, b ($0 \le a, b \le 2000000000$), a is the cost of building the wall between it and its lower adjacent square, and b is the cost of building the wall between it and its right adjacent square. If the side is a boundary, the lacking path will be replaced with X 0.

The next line contains an integer Q ($1 \le Q \le 100000$), which represents the number of questions.

The next Q lines give four integers, x_1, y_1, x_2, y_2 ($1 \le x_1, x_2 \le N$, $1 \le y_1, y_2 \le M$), which represent two squares and their coordinates are (x_1, y_1) and (x_2, y_2).

(x, y) means row x and column y.

It is guaranteed that there is only one kind of maze.

Output

For each question, output one line with one integer which represents the length of the shortest path between two given squares.

Examples

Input

```
3 3
D 1 R 9
D 7 R 8
D 4 X 0
D 2 R 6
D 12 R 5
D 3 X 0
X 0 R 10
X 0 R 11
X 0 X 0
3
1 1 3 3
```

```
1 2 3 2
2 2 3 1
```

Output

```
4
2
2
```

Source

ACM-ICPC 2018 Xuzhou Online

Very Important Edge

You are given a simple connected graph where each edge is assigned a non-negative weight. Recall that a minimum spanning tree of a graph is a connected, acyclic subset of the edges of the graph with minimum total weight. Find an edge which maximizes the minimum spanning tree weight of a given graph if that edge is deleted. It is guaranteed that the input graph remains connected after deleting any one edge.

Input

The first line of input contains two integers n ($3 \le n \le 10^5$) and m ($3 \le m \le 10^6$), where n is the number of vertices and m is the number of edges in the input graph. The vertices are numbered from 1 to n.

Each of the next m lines contains three integers a, b ($1 \le a < b \le n$) and w ($1 \le w \le 10^6$). This denotes an edge between vertices a and b with weight w.

Output

Output a single integer, which is the minimum spanning tree weight of the input graph after the right edge is deleted.

Examples

Input

```
3 3
1 2 1
2 3 2
1 3 2
```

Output

```
4
```

Input

```
4 5
2 3 5
1 2 2
1 3 4
1 4 2
3 4 3
```

Output

```
10
```

Input

```
5 7
2 5 8
1 3 19
```

```
4 5 9
1 5 15
1 2 14
3 4 16
2 4 15
```

Output

```
54
```

Source

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