CCC '15 S4 - Convex Hull

Canadian Computing Competition: 2015 Stage 1, Senior #4

You are travelling on a ship in an archipelago. The ship has a convex hull which is K centimetres thick. The archipelago has N islands, numbered from 1 to N. There are M sea routes amongst them, where the ith route runs directly between two different islands a_i and b_i; ($1 \leq a_i, b_i \leq N$), takes t_i minutes to travel along in either direction, and has rocks that wear down the ship's hull by h_i centimetres. There may be multiple routes running between a pair of islands.

You would like to travel from island A to a different island B ($1 \leq A, B \leq N$) along a sequence of sea routes, such that your ship's hull remains intact – in other words, such that the sum of the routes' h_i values is strictly less than K.

Additionally, you are in a hurry, so you would like to minimize the amount of time necessary to reach island B from island A. It may not be possible to reach island B from island A, however, either due to insufficient sea routes or the having the ship's hull wear out.

Input Specification

The first line of input contains three integers K, N and M ($1 \leq K \leq 200, 2 \leq N \leq 2\,000, 1 \leq M \leq 10\,000$), each separated by one space.

The next M lines each contain 4 integers a_i, b_i, t_i and h_i ($1 \leq a_i, b_i \leq N, 1 \leq t_i \leq 10^5, 0 \leq h_i \leq 200$), each separated by one space. The ith line in this set of M lines describes the ith sea route (which runs from island a_i to island b_i, takes t_i minutes and wears down the ship's hull by h_i centimetres). Notice that $a_i \neq b_i$ (that is, the ends of a sea route are distinct islands).

The last line of input contains two integers A and B ($1 \leq A, B \leq N; A \neq B$), the islands between which we want to travel.

For 20% of marks for this question, $K = 1$ and $N \leq 200$. For another 20% of the marks for this problem, $K = 1$ and $N \leq 2\,000$.

Output Specification

Output a single integer: the integer representing the minimal time required to travel from A to B without wearing out the ship's hull, or `-1` to indicate that there is no way to travel from A to B without wearing out the ship's hull.

Sample Input 1

```
10 4 7
1 2 4 4
1 3 7 2
3 1 8 1
3 2 2 2
4 2 1 6
3 4 1 1
1 4 6 12
1 4
```

Output for Sample Input 1

```
7
```

Explanation of Output for Sample Input 1

The path of length 1 from 1 to 4 would wear out the hull of the ship. The three paths of length 2 ($[1,2,4]$ and $[1,3,4]$ two different ways) take at least 8 minutes. The path $[1,2,3,4]$ takes 7 minutes and only wears down the hull by 7 centimetres, whereas the path $[1,3,2,4]$ takes 13 minutes and wears down the hull by 5 centimetres.

Sample Input 2

```
3 3 3
1 2 5 1
3 2 8 2
1 3 1 3
1 3
```

Output for Sample Input 2

```
-1
```

Explanation of Output for Sample Input 2

The direct path $[1,3]$ wears down the hull to 0, as does the path $[1,2,3]$.