WOBURNCHALLENGE

2017-18 Online Round 4

Friday, April 20th, 2018

Intermediate Division Problems

Problem I1: The Infinity Stones

*13 Points / Time Limit: 2.00s / Memory Limit: 16M*   *Submit online: http://wcipeg.com/problem/wc174j3*

The Infinity Stones… A set of six ancient gems with unrivaled power, scattered across the galaxy. Possessing all six would surely grant one the power to rule over all life with no opposition. Which is exactly what Thanos intends to do!

The six Infinity Stones are referred to by the following names in alphabetical order:

    Mind
    Power
    Reality
    Soul
    Space
    Time

Thanos is already in possession of N ($0 \leq N \leq 6$) of the Infinity Stones, the i-th of which is S_i. Each stone is guaranteed to be one of the six mentioned above, the stones may be listed in any order, and no stone is listed multiple times.
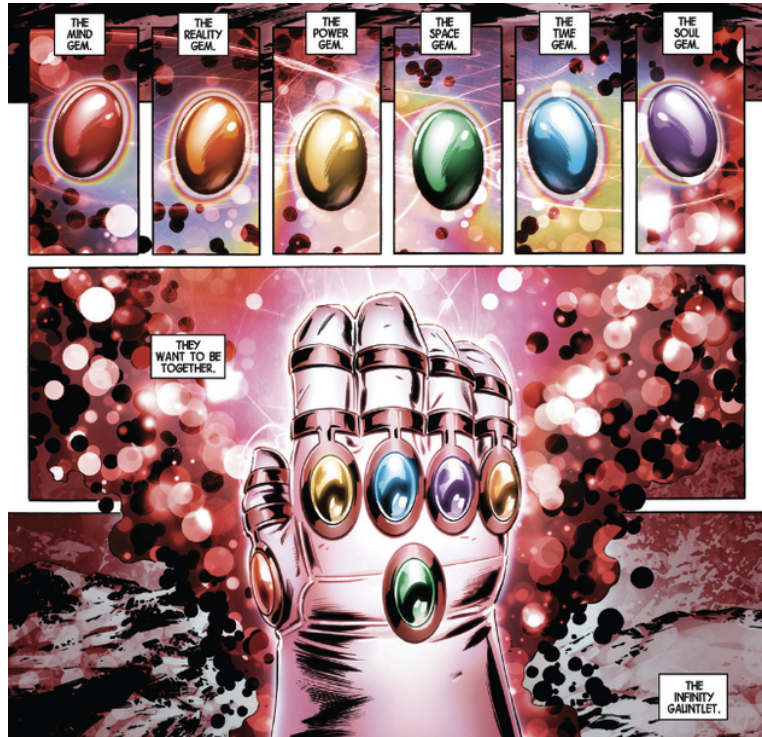
Thanos intends to wage a war against the Avengers and anyone else foolish enough to try to stop him, while finishing his search for the remaining Infinity Stones. Determine the names of the $6 - N$ remaining stones which Thanos doesn't yet possess, in alphabetical order.

Subtask: In test cases worth 6/13 of the points, $N = 1$.

Input Format

The first line of input consists of a single integer, N.
N lines follow, the i-th of which consists of a single string, S_i, for $i = 1..N$.

Output Format

Output $6 - N$ lines, the i-th of which consists of a single string corresponding to the name of the i-th stone (in alphabetical order) which Thanos doesn't possess.

Sample Input

```
1
Soul
```

Sample Output

```
Mind
Power
Reality
Space
Time
```

Sample Explanation

Thanos already has the Soul Stone, so he still needs the other five.

Problem I2: Efficiency

17 Points / Time Limit: 2.00s / Memory Limit: 16M   *Submit online: http://wcipeg.com/problem/wc174j4*

An invasion of Earth is underway, marking the beginning of the Infinity War! Thanos has dispatched a legion of cybernetically enhanced Chitauri soldiers to a field in rural America, ordering them to stand by for further instructions. As luck would have it, the Avengers' expert archer Hawkeye happens to be standing in the same field! Though perhaps he's not so lucky after all, as he's only stocked with a single arrow.

Looking at the field from above, it can be represented as a grid with R rows and C columns ($1 \le R, C \le 50$), aligned with the four cardinal directions (North/East/South/West). The contents of each of the grid's cells can then be represented by one of three characters:

- "H": Hawkeye's location
- "C": A Chitauri soldier's location
- ".": Empty space

Note that the grid contains exactly one "H".

Thinking quickly, Hawkeye has realized that he'll need to be as efficient as possible with his single arrow. He can choose to fire it in a straight line from his location, exactly in one of the four cardinal directions (North, East, South, or West). Upon releasing the arrow, it will travel through all of the cells in the chosen direction until it reaches the edge of the field, even freely passing through (and killing) any Chitauri soldiers along the way.

Assuming that Hawkeye chooses the best cardinal direction to fire his arrow in, what's the largest number of Chitauri soldiers which he can kill?

Input Format

The first line of input consists of two space-separated integers, R and C.
R lines follow, the i-th of which consists of C characters representing the i-th row of the grid, for $i = 1..R$.

Output Format

Output a single integer, the maximum number of Chitauri soldiers which Hawkeye can kill.

Sample Input	Sample Output	Sample Explanation
4 5 .CCC. C.... C.CHC ..C..	2	Hawkeye will kill two soldiers if he fires his arrow to the West.

Problem I3: Wakandan Sabotage

*30 Points / Time Limit: 2.00s / Memory Limit: 64M*   *Submit online: http://wcipeg.com/problem/wc174s1*

The Infinity War has begun! Black Panther is well aware of the importance of rallying his supporters together to help defend Earth from the evil Thanos, so he's working on unifying the Wakandan army. Unbeknownst to him, however, Loki has formed a secret alliance with Thanos and is planning on sabotaging Black Panther's efforts.

The nation of Wakanda consists of $N \times M$ cities ($2 \le N, M \le 1000$), arranged in an grid with N rows and M columns. In each of the M columns of the grid, there are $N - 1$ vertical roads connecting pairs of vertically-adjacent cities. Additionally, in the bottom-most and top-most rows only, there are $M - 1$ horizontal roads connecting pairs of horizontally-adjacent cities. As such, there are $M(N - 1) + 2(M - 1)$ roads in total throughout Wakanda. Each road is exactly 1 km long.

For example, if $N = 2$ and $M = 4$, the network of cities and roads looks as follows:
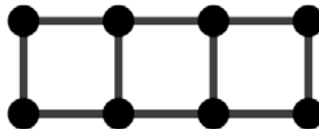
Loki has the explosive resources to destroy K ($0 \le K < M(N - 1) + 2(M - 1)$) roads of his choice. He'd hate for any of his explosives to go to waste, so he'll destroy exactly K roads, no fewer.

Upon realizing that some roads have been destroyed, Black Panther will still do his best to assemble the Wakandan army together. He'll ask soldiers to travel amongst various cities which are still connected by the remaining roads. Overall, the amount of time required for this mobilization will depend on a single factor – the maximum shortest distance (along undestroyed roads) between any pair of cities which are still reachable from one another at all. In other words, if $D_{i,j}$ is equal to the shortest distance between cities i and j if they're connected by roads (or is equal to 0 if they're not connected), then the value of importance is $\max\{D_{i,j}\}$ over all pairs of cities (i, j).

For example, if Loki were to destroy the two roads indicated in red below, then the maximum shortest path between any pair of connected cities would be 3 km long (for example, between the two cities marked in green, along the roads indicated in blue).
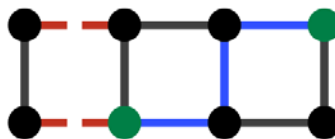
Naturally, Loki is interested in selecting a set of K roads to destroy such that this value is maximized. Help him determine the maximum possible shortest distance between any pair of connected cities which his sabotage can result in.

Subtasks

In test cases worth 16/30 of the points, $N = 2$.

Input Format

The first and only line of input consists of three space-separated integers, N, M, and K.

Output Format

Output a single integer, the maximum achievable shortest distance between any pair of cities which are still connected (in km).
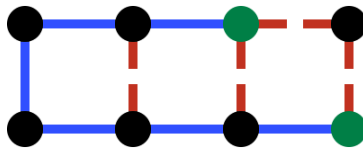
Sample Input

```
2 4 4
```

Sample Output

```
6
```

Sample Explanation

Loki may choose to destroy the four roads indicated in red below. The shortest path between the pair of cities marked in green would then be 6 km long (consisting of the roads indicated in blue).

Problem I4: Strange Travels

40 Points / Time Limit: 4.00s / Memory Limit: 64M   *Submit online: http://wcipeg.com/problem/wc174s2*

Desperate to find more allies to join in the fight against Thanos, the Avengers have requested assistance from Doctor Strange, a powerful magician. Strange is willing to help, but he'll need some assistance of his own first. To fully apply his powers to the fight, he'll need to gather together a set of artifacts from hidden sanctums around the world!

There are N ($2 \leq N \leq 100,000$) sanctums, numbered from 1 to N, spread out all across the Earth. It would take far too long to travel amongst them by conventional means, but Doctor Strange has access to a convenient alternative – magical portals. There are M ($0 \leq M \leq 200,000$) one-way portals, with the i-th of them allowing for instantaneous travel from sanctum A_i to B_i ($1 \leq A_i, B_i \leq N, A_i \neq B_i$). No two portals connect the same pair of sanctums in the same direction.

There are K ($1 \leq K \leq N - 1$) artifacts which Strange requires, with the i-th of them being held in sanctum S_i ($2 \leq S_i \leq N$). No artifact is in sanctum 1, and no two artifacts are located in the same sanctum.

Doctor Strange is initially located in sanctum 1, also known as the Sanctum Sanctorum. He'll need to recover all K artifacts back to the Sanctum Sanctorum, one by one. In particular, for each artifact i in order, he'll need to warp through a sequence of 1 or more portals to reach sanctum S_i, collect the artifact, and then warp through a sequence of 1 or more portals to return to sanctum 1 before heading back out for the next one. Note that he may not carry multiple artifacts at a time, and must collect the K artifacts in order. Overall, he'll be required to visit the following sequence of sanctums:

$$1 \rightarrow S_1 \rightarrow 1 \rightarrow S_2 \rightarrow 1 \rightarrow \dots \rightarrow 1 \rightarrow S_K \rightarrow 1$$

Determine the minimum number of portal warps which Doctor Strange will need to perform to achieve his goal. Unfortunately, it may instead turn out to be impossible to visit the entire required sequence of sanctums, in which case you should output –1 instead.

Subtasks

In test cases worth 12/40 of the points, $N \leq 100$ and $M \leq 2000$.
In test cases worth another 12/40 of the points, $N \leq 2000$ and $M \leq 2000$.

Input Format

The first line of input consists of two space-separated integers, N and M.
M lines follow, the i-th of which consists of two space-separated integers, A_i and B_i, for $i = 1..M$.
The next line consists of a single integer K.
K lines follow, the i-th of which consists of a single integer, S_i, for $i = 1..K$.

Output Format

Output a single integer, either the minimum number of warps required to recover all of the artifacts, or −1 if not all of them can be recovered.

Sample Input 1

```
4 6
1 2
2 3
3 1
1 3
4 3
3 4
2
4 2
```

Sample Output 1

```
7
```

Sample Input 2

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

Sample Output 2

```
-1
```

Sample Explanations

In the first case, Doctor Strange can warp through the following sequence of sanctums:

$1 \rightarrow 3 \rightarrow 4 \rightarrow 3 \rightarrow 1 \rightarrow 2 \rightarrow 3 \rightarrow 1$

In the second case, Doctor Strange would be able to recover the first artifact and then reach the second one, but he would then be unable to return to sanctum 1 with it.