ETH Zurich
Institut für Theoretische Informatik
Prof. Dr. Angelika Steger
Prof. Dr. Emo Welzl
Prof. Dr. Peter Widmayer

Algorithms Lab

Exercise – *Planet Express*

It is year 3000 and you are an employee of the Planet Express delivery company. A customer from planet *Omicron Persei 8* just ordered one yottagram of dark matter using the "same-second" delivery option and you have been given the task of (quickly) planning the delivery.

Planet Express stores dark matter in $k > 0$ warehouses scattered on planets across the galaxy, and you can initiate the delivery process by choosing any of the warehouses and activating one if its robotic delivery agents.

The galaxy can be modelled as a weighted directed graph $G = (V, E)$, where $V = \{0, \ldots, n-1\}$, and $|E| = m$. Each vertex of G represents a planet while an edge (u, v) of weight c means that it is possible to *travel* from planet u to planet v in c microseconds[1]. The k warehouses reside on planets $0, \ldots, k-1$ while Omicron Persei 8 always corresponds to vertex $n-1$.

In addition, T of the planets are also part of a convenient *teleportation network*. Unfortunately, the teleportation technology still requires the source and destination planets to be reachable from one-another by regular means of travel. More precisely, we say that two *distinct* planets u and v **that are *both* part of the teleportation network** are *linked* if it is possible to reach v from u and vice-versa without using the teleportation network. An agent on planet u can *teleport* to the location of any another planet v that is linked with u in just $t(u)$ microseconds, where $t(u)$ is the total number of planets that are linked with u.

Once activated, the delivery agent will deliver the dark matter to the customer in the shortest possible time, travelling between planets and/or using the teleportation network.

Your task is to determine whether it is possible for Planet Express to complete the delivery within the advertised time of 1 second and, if that is the case, the shortest amount of time required for the delivery. You can assume that the time needed to travel between two locations on the same planet is negligible.

Input The first line of the input contains the number $t \leq 20$ of test cases. Each of the t test cases is described as follows.

- It starts with a line containing four integers `n m k T`, separated by a space. They denote
  - **n** The number of planets in the galaxy or, equivalently, the number of vertices of G ($1 \leq n \leq 10^5$);
  - **m** The number of edges of G ($0 \leq m \leq 10^5$);
  - **k** The number of warehouses, corresponding to vertices $0, \ldots, k-1$ in G ($1 \leq k \leq n$);
  - **T** The number of planets that are part of the teleportation network ($0 \leq T \leq n$);
- The following line contains T distinct integers $\mathtt{t}_0 \ldots \mathtt{t}_{T-1}$ with $0 \leq t_i < n$. This denotes that the vertices (planets) $t_0, \ldots, t_{T-1}$ of G are part of the teleportation network.

[1] A microsecond is equal to 10^{-6} seconds. Spaceships are fast!

- The next m lines define the edges of G. Each line contains three integers `u v c` meaning that G contains a directed edge (u, v) of weight c. Here $0 \leq u, v < n$, $u \neq v$, and $0 \leq c \leq 10^7$.

Output The output consists of one line for each test case.

- If in the i-th test case the dark matter cannot be delivered in at most 1 second, then the i-th line of the output should contain the string "`no`".
- Otherwise, the i-th line of the output should contain a single integer that denotes the smallest number of microseconds needed to complete the delivery (i.e., the time needed be the delivery agent to reach Omicron Persei 8 once the best warehouse has been selected).

Points There are four groups of test sets worth 20, 30, 30, and 20 points respectively.

1. For the first group of test sets, you may assume that $n, m \leq 10^4$, and $k, T \leq 20$.
2. For the second group of test sets, you may assume that $T \leq 800$.
3. For the third group of test sets, there are no additional assumptions.
4. For the fourth group of test sets, which is hidden, there are no additional assumptions.

Corresponding sample test sets are contained in `test`i`.in/out`, for $i \in \{1, 2, 3\}$.

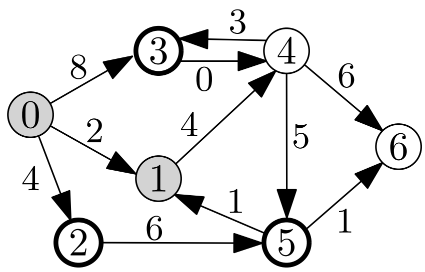
Sample Input

```
2
7 11 2 3
2 3 5
0 1 2
0 2 4
0 3 8
1 4 4
2 5 6
3 4 0
4 3 3
4 5 5
4 6 6
5 1 1
5 6 1
5 6 2 2
2 3
0 1 5
0 3 1000001
1 2 999500
2 0 0
3 0 100
3 4 500
```

Sample Output

```
9
no
```

Example In the following example, corresponding to the first test case of the sample input, $n = 7$, $m = 11$, $k = 2$, and $T = 3$. Vertices that represent warehouses are shown in gray. Vertices that are part of the teleportation network are shown in bold.



An optimal solution delivers the black matter from warehouse 1. The required delivery time is $4+3+1+1 = 9$ microseconds and is attained by traversing the sequence of vertices $\langle 1, 4, 3, 5, 6 \rangle$. Notice that the teleportation network has been used in order to travel from planet 3 to planet 5.