

CS F211

Data Structures and Algorithms

Assignment - 9

Trees

Allowed Language: C

March 21, 2024

General Tips

- Try to use functions as much as possible in your code. Functions increase reusability and the pass-by-value feature provides a significant help sometimes. Modularizing your code also helps you to debug efficiently.
- Use `scanf` to read characters/strings from STDIN. Avoid using `getchar`, `getc` or `gets`. Try to read up about character suppression in `scanf` as it will be very helpful in some of the problems.
- Use `printf` instead of `putc`, `putchar` or `puts` to print character/string output on STDOUT.
- Indent your code appropriately and use proper variable names. These increase readability and writability of the code. Also, Use comments wherever necessary.
- Use a proper IDEs like Sublime Text or VSCode as they help to run and test your code on multiple test-cases easily.
- **Note:** Kindly try to do all of these questions by yourself at least once. Spend some time thinking about it, or trying to code it instead of directly asking help of your friends or searching it up online. This helps you understand the question, allowing you to solve further questions which are not in the scope of this Assignment yourself.

Regulations for Binary Trees

- The asked time complexity, if any, excludes reading the input and printing the output.
- If the input for the problem is a binary tree, it will be provided as an array of integers, unless stated otherwise. Assume 1-based indexing for the array.
- The elements of the array will contain the values of the nodes.
- The values of the nodes are guaranteed to be non-negative integers. The values may not be unique.
- The 1-st element of the array will contain the value of the root node.
- The $(2i)$ -th and $(2i + 1)$ -th elements will contain the values of the left child and right child of the node corresponding to the i -th element, respectively.
- If $(2i)$ or $(2i + 1)$ is greater than the size of the array then the corresponding child node does not exist.
- If an element of the array has value -1, then the corresponding node does not exist.
- It is recommended that you define a self-referential structure for one node of the binary tree and construct the binary tree using it from the given input. However, it is not necessary to do so.

A: Midsem Sadness

Since Kira left the college after scoring bad in DSA Midsem, Nom sat on the root of a tree to mourn the loss of his friend. Nom was sitting on top of a tree, i.e., its root, since the tree is of DSA kind. When he looked below, he saw lots of Peanut Butter jars in different nodes of the tree having weights equal to the node value of the tree.

Now, Nom can start at any node of the tree, and will follow a path such that he gets the maximum weight of Peanut Butter possible in a path to make him happy. Help Nom find this path and get over Kira.

A path in a tree is a sequence of nodes where each pair of adjacent nodes in the sequence has an edge connecting them. A node can only appear in the sequence at most once. Note that the path does not need to pass through the root.

Input

The first line contains one positive integer n ($1 \leq n \leq 10^6$) - the size of the array representing the binary tree.

The second line contains n space separated integers a_1, a_2, \dots, a_n ($1 \leq a_i \leq 10^9$) - representing the weights of Peanut Butter jars.

Output

Print a single integer, maximum path sum of the weights of Peanut Butter jars across the optimum path.

input

7

1 2 3 4 5 6 7

output

18

explanation

Consider the path: 5->2->1->3->7, it has a weight 18.

input

8

8 12 13 -1 -1 6 7 5

output

44

B: Poker Hands

Nom and Akshoe were playing Poker the other day. Akshoe was new to it so Nom explained the hands to him. According to Nom's rules, you are given a community tree (a) and a tree in hand (b). If the tree in hand is a perfect subtree of the community tree, you win. Otherwise, you lose.

A subtree of a binary tree is a tree that consists of a node in tree and all of this node's descendants. The tree could also be considered as a subtree of itself.

Given community tree and tree in hand, find whether you will win or lose.

Input

The first line contains two positive integers n, m ($1 \leq m \leq n \leq 10^6$) - the size of the array representing the two binary trees.

The second line contains n space separated integers a_1, a_2, \dots, a_n ($1 \leq a_i \leq 10^9$).

The second line contains m space separated integers b_1, b_2, \dots, b_m ($1 \leq b_i \leq 10^9$).

Output

Print "WIN" if you win, otherwise "LOSS".

input

7 3

1 2 3 4 5 6 7

3 6 7

output

WIN

input

8 3

8 12 13 -1 -1 6 7 5

13 6 7

output

LOSS

C: TollyWood

After dropping out of college, Kira decided to become a Tollywood star like DJ Tillu. But he ended up becoming a Wood-Cutter. He cut trees for a living. More the height of the tree, more the money he'd get, thus allowing him to earn money to pursue his dream of becoming DJ Tillu's right shoe.

Since Kira has a lot of skill issue, he cut a random node of the tree he cut earlier, which may or may not have reduced its height. Once a node is cut, the entire subtree will be gone. Help Kira find the height of the remaining tree to calculate his expenses.

Input

The first line contains two positive integers n, k ($1 \leq n \leq 10^6, 1 \leq k \leq 10^9$) - the size of the array representing the binary tree and the node which Kira cut off earlier.

The second line contains n distinct space separated integers a_1, a_2, \dots, a_n ($1 \leq a_i \leq 10^9$).

Output

Print a single integer - height of the remaining tree.

input

7 3

1 2 3 4 5 6 7

output

3

explanation

Consider the path: 1->2->4, it has a height 3.

input

8 13

8 12 13 -1 -1 6 7 5

output

2

D: Order Order - Easy Version

Since everyone thought that Assignment 8 was very easy, Nom and Kira decided to give the toughest problem known to humanity.

The objective of this problem is to create a tree using its Inorder and Preorder traversals. Nom and Kira wish you all the best for this problem.

Input

The first line of input contains n ($1 \leq n \leq 3000$) — the size of arrays a and b .

The second line of input contains n space separated integers a_1, a_2, \dots, a_n ($1 \leq a_i \leq 10^9$) which denotes the Inorder traversal of the tree

The third line of input contains n space separated integers b_1, b_2, \dots, b_n ($1 \leq b_i \leq 10^9$) which denotes the Preorder traversal of the tree

Each value of a also appears in b .

Output

Print the Level-Order Traversal of the tree (with -1 where a node points to NULL).

input

5

3 9 20 15 7

9 3 15 20 7

output

3 9 20 -1 -1 15 7

input

6

1 2 3 4 5 6

4 2 1 3 5 6

output

4 2 5 1 3 -1 6

E: Order Order - Hard Version

Now, since you solved problem D, Nom decided to give even a harder problem. Given a Postorder traversal of a Binary Search Tree, reconstruct it.

Input

The first line of input contains n ($1 \leq n \leq 3000$) — the size of arrays a .

The second line of input contains n space separated integers a_1, a_2, \dots, a_n ($1 \leq a_i \leq 10^9$) which denotes the Postorder traversal of the tree

Output

Print the Level-Order Traversal of the tree.

input

5

1 2 5 4 3

output

3 2 4 1 -1 -1 5

input

3

1 3 2

output

2 1 3

F: OS is Hard, but not when you Repeat

Nom was doing Compilers Assignment. He found some n errors in his code. He numbered them according to their priority and designed a tree, which showed which error was derived from which larger error. Kira told him that if you fix the some m -th lowest priority error, then all the lesser priority errors will be fixed on their own. He also tells him that the lowest node value will be the highest priority and vice versa.

Nom thus decides to fixed the k -th least priority error. Help Nom find the node's value of that error.

Input

The first line contains two positive integers n, k ($1 \leq k \leq n \leq 10^6$) - the size of the array representing the binary search tree and the k mentioned in the problem.

The second line contains n distinct space separated integers a_1, a_2, \dots, a_n ($1 \leq a_i \leq 10^9$).

Output

Print a single integer - value of the k -th largest node.

input

7 3

4 2 6 1 3 5 7

output

5

input

8 5

8 2 13 1 7 -1 -1 5

output

2

G: BOSS of BPHC

A company has n employees, who form a tree hierarchy where each employee has a boss, except for the general director. You being the general director's son, want to find out who your friends report to.

Your task is to find who is the lowest common boss of employees A and B in the hierarchy?

Input

The first line contains three positive integers n, A, B ($1 \leq n \leq 10^6, 1 \leq A, B \leq 10^9$) - the size of the array representing the binary tree and the value of the nodes A and B.

The second line contains n distinct space separated integers a_1, a_2, \dots, a_n ($1 \leq a_i \leq 10^9$).

Output

Print a single character - the initial of the person most recently by A and B.

input

7 2 3

1 2 3 4 5 6 7

output

1

input

8 7 5

8 12 13 -1 -1 6 7 5

output

13

H: Travelling Panda Problem

Nom travels to Europe and wants to visit all the countries there. So, he decides to make an itinerary about which country he could visit via the first country he started at in some order.

He made a Binary Tree to visualize his travel itinerary, where the first country was the root node, where he was at. And he connected the other countries with each other via some edges. Find the sum of distance from the root country node to all other country nodes.

Input

The first line contains one positive integer n ($1 \leq n \leq 10^6$) - the size of the array representing the binary tree.

The second line contains n distinct space separated integers a_1, a_2, \dots, a_n ($1 \leq a_i \leq 10^9$).

Output

Print a single integer - sum of all distances from root to other nodes.

input

7

1 2 3 4 5 6 7

output

10

explanation

Distances to each node are as follows : [0,1,1,2,2,2,2]

input

8

8 12 13 -1 -1 6 7 5

output

9

explanation

Distances to each node are as follows : [0,1,1,NA,NA,2,2,3]

I: RBT - Real BT

Everyone knows that Red-Black Trees are tough and boring, but they are really important to clear your concepts of self-balancing Binary Search Trees.

You are given an unsorted array, out of which you are required to make a Red-Black Tree. Once you are done constructing the RBT print the Level-Order Traversal of the RBT.

Input

The first line contains two positive integers n ($1 \leq n \leq 10^6$) - the size of the unsorted array. The second line contains n distinct space separated integers a_1, a_2, \dots, a_n ($1 \leq a_i \leq 10^9$), such that they are inserted in this order.

Output

Print the Level-Order Traversal of the Red-Black Tree.

input

5

1 2 3 4 5

output

2 1 4 -1 -1 3 5

input

3

1 2 3

output

2 1 3

J: Life is a Lie

So, Nom was doing an overseas research thesis, and during that he found out a research paper published by Kira's mentor Jilind. That paper was over 100 pages long and was trying to prove how a Binary Tree is a Circle. Nom headed towards the Himalayas.

But the question that remains is, what would the diameter of the binary tree be? The diameter of a binary tree is the length of the longest path between any two nodes in a tree. This path may or may not pass through the root. Solve this problem and wish that Nom does not become a sage.

Refer Problem A for the definition for a path. The length of a path is the number of edges between the two end nodes of that path.

Input

The first line contains two positive integers n, k ($1 \leq n \leq 10^6$) - the size of the array representing the binary tree.

The second line contains n distinct space separated integers a_1, a_2, \dots, a_n ($1 \leq a_i \leq 10^9$).

Output

Print the length of the diameter of the Tree.

input

7

1 2 3 4 5 6 7

output

4

explanation

Consider the path: 5->2->1->3->7, it has a length 4.

input

8

8 12 13 -1 -1 6 7 5

output

4
