Coding Assignment 2: CS2233

September 18, 2025

Kindly adhere to the following instructions.

- Please write a C/C++ program corresponding to each problem. Your code should be well commented and variable names should be appropriately chosen. Also prepare a `readme` text file where you can mention instructions to run the program/how to take input etc.
- Create a folder and put all the code files and `readme` text file in it, give name to the folder as "yourName_yourRollNo", zip the folder and submit it to the google classroom portal.
- Strictly follow the input and output format for each problem.
- Any code that does not follow the input-output criteria won't be evaluated and will get **ZERO**.
- Your code will also be checked against plagiarism (both from web and peer).
- Any form of plagiarism (web/chatGPT/with peers) will be severely penalised and will result in F grade.
- The submission (strict) timeline is 3rd October, Friday, 11 AM.
- Each question consists of 10 marks.

General Instruction

The description of the *array representation of a tree* is as follows:

- Array index starts with 1.
- The left and right children of the i^{th} node present in the $2i^{th}$ and $(2i+1)^{th}$ index, respectively.
- If let's say left child of the i^{th} node is empty then the $2i^{th}$ index of array contains $NULL$, similarly for the right child also.
- For example, See the following images.

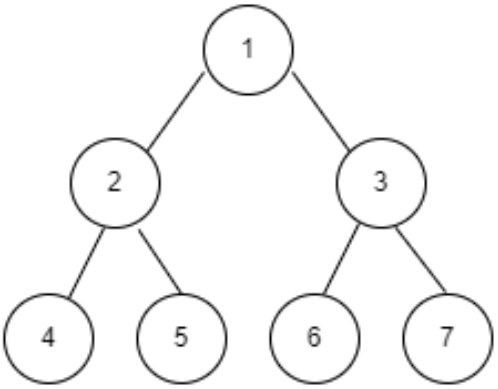
1. Write a non-recursive implementation of `inorder, preorder, postorder` traversal.

   Input format

   - First line will contain k, which indicates the number of test cases.
   - Following k lines will contain arrays of integers, denoting the array representation of a tree.

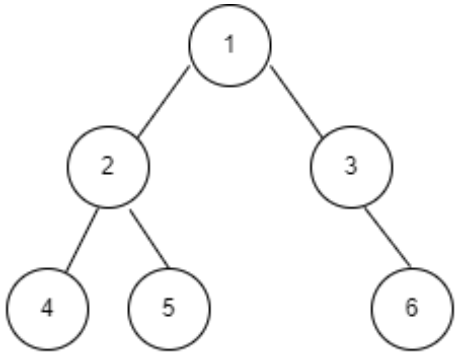
   Output format

   - Your output also should contain $3k$ lines, which indicates the output of corresponding k inputs.
   - For each input, first line contains the `inorder` traversal, second line contains the `preorder` traversal, and third line contains the `postorder` traversal.



1	2	3	4	5	6	7

Array representation of the above tree



1	2	3	4	5	NULL	6

Array representation of the above tree

Example:
Input:

```
2
1 2 3 4 5 6 7
1 2 3 4 5 NULL 6
```

Output:

```
4 2 5 1 6 3 7   %inorder traversal of 1st tree%
1 2 4 5 3 6 7   %preorder traversal of 1st tree%
4 5 2 6 7 3 1   %postorder traversal of 1st tree%
4 2 5 1 3 6     %inorder traversal of 2nd tree%
1 2 4 5 3 6     %preorder traversal of 2nd tree%
4 5 2 6 3 1     %postorder traversal of 2nd tree%
```

Note: %comments% are there for your understanding, you need not print this.

2. Write a C program that takes `inorder` and `preorder` traversal as input, output the tree. You need to print the array representation of the tree. Your code should output an error message if the `inorder` and `preorder` are not corresponding to the same tree.

   Input format

   - First line will contain k, which indicates the number of test cases.
   - Following $2k$ lines will contain integers of each $2k$ arrays.
   - $(2i-1)^{th}$ line contains the `inorder` traversal for the i^{th} test case.
   - $2i^{th}$ line contains the `preorder` traversal for the i^{th} test case.

   Output format

   - Your output also should contain k lines, which indicates the output of corresponding k tree inputs.
   - Each line will contain the array representation of the tree as described in the general instruction.
   - If the `inorder` and `preorder` are not corresponding to the same tree, then print `ERROR`.

Example:
Input:

```
3
4 2 5 1 6 3 7   %inorder traversal of 1st tree%
1 2 4 5 3 6 7   %preorder traversal of 1st tree%
4 2 5 1 3 6     %inorder traversal of 2nd tree%
1 2 4 5 3 6     %preorder traversal of 2nd tree%
4 2 6 1 3 5     %inorder traversal of 3rd tree%
1 2 4 5 3 6     %preorder traversal of 3rd tree%
```

Output:

```
1 2 3 4 5 6 7
1 2 3 4 5 NULL 6
ERROR
```

Note: %comments% are there for your understanding.

3. **Most Frequent Pair Distance in a Binary Tree** : Given a binary tree with n nodes, find the distance that occurs most frequently. If there is a tie, return the smallest distance.

   Input format

   - First line: integer n, the number of nodes.
   - Second line: n space-separated integers for Preorder traversal.
   - Third line: n space-separated integers for Inorder traversal.

   Output format

   - A single integer: the most frequent distance.

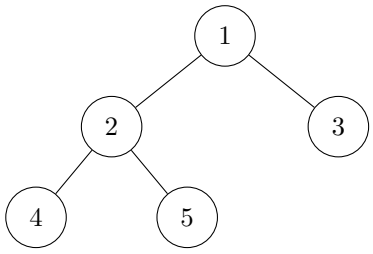
   Expected Time Complexity : $O(n^2)$

   Example:

```
Input:
5
1 2 4 5 3
4 2 5 1 3

Output:
1
```

   Explanation: The tree reconstructed from the traversals is shown below:



   After calculating all 10 pairwise distances, the frequencies are:

- **Distance 1:** 4 times (e.g., d(1,2), d(1,3), d(2,4), d(2,5))
- **Distance 2:** 4 times (e.g., d(1,4), d(1,5), d(2,3), d(4,5))
- **Distance 3:** 2 times (d(3,4), d(3,5))

A tie exists between distances 1 and 2. Per the rule, the smallest tied distance is chosen.

4. **Longest Equal-Value Path in a Binary Tree :** You are given a binary tree with n nodes, where each node contains an integer value. A path is defined as a sequence of connected nodes (via edges) in the tree, where each step moves either from a parent to a child or from a child to a parent. A path is called **equal-value** if all nodes in the path have the same value.

   Your task is to find the **length (number of nodes)** of the longest equal-value path in the tree.

Input Format

- The first line contains an integer n — the number of nodes.
- The next line contains n integers — the values of the nodes (1-indexed).
- The next $n-1$ lines each contain two integers u, v representing an undirected edge between nodes u and v, where u and v are the 1-based indices of the nodes as given in the second line of input.

Output Format

Print a single integer — the length of the longest equal-value path.

Example 1
Input:

```
6
5 5 5 5 1 5
1 2
1 3
2 4
3 5
3 6
```

Output:

```
5
```

Explanation: The longest path with value 5 is $4 \to 2 \to 1 \to 3 \to 6$, containing 5 nodes.

Example 2
Input:

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

Output:

```
4
```

Explanation: The longest path with value 2 is $3 \to 1 \to 2 \to 5$, containing 4 nodes.

5. **K-th Node on the Path in a BST** : You are given a Binary Search Tree (BST) and two distinct nodes u and v. There exists a **unique path** between u and v in the BST.

   Your task is to find the k**-th node on this path** (counting from u). If no such node exists, print `-1`. Multiple queries (u, v, k) may be asked.

   Input Format

   - The first line contains an integer n — the number of nodes in the BST.
   - The next line contains n integers — the node values (inserted in order into the BST).
   - The next line contains an integer q — the number of queries.
   - The following q lines each contain three integers: u, v, k. $(k > 0)$

   Output Format

   - For each query, print the k-th node on the path from u to v, or `-1` if it does not exist.

   Example 1
   Input:

   ```
   7
   4 2 6 1 3 5 7
   2
   1 7 3
   3 5 2
   ```

   Output:

   ```
   6
   5
   ```

   Example 2
   Input:

   ```
   5
   10 5 15 3 7
   3
   3 15 4
   7 5 2
   10 7 4
   ```

   Output:

   ```
   15
   5
   -1
   ```

6. **Range Sum of BST:** You are given the root node of a Binary Search Tree (BST) and two integers `low` and `high`. Your task is to return the **sum of values of all nodes** with a value in the **inclusive range** $[low, high]$.

   Input Format

- The first line contains the array representation of the BST.
- The next line contains two integers — `low` and `high`.

Output Format

- Print the sum of node values that lie in the range $[low, high]$.

Example 1

Input:

```
10 5 15 3 7 null 18
7 15
```

Output:

```
32
```

Explanation: Nodes 7, 10, and 15 are in the range $[7, 15]$. Sum $= 7 + 10 + 15 = 32$.

Example 2

Input:

```
10 5 15 3 7 13 18 1 null 6
6 10
```

Output:

```
23
```

Explanation: Nodes 6, 7, and 10 are in the range $[6, 10]$. Sum $= 6 + 7 + 10 = 23$.