Experiment-5

Student Name: Dharmesh Kumar **UID:** 22BCS10126
Branch: BE-CSE **Section/Group:** 22BCS_IOT-638/B
Semester: 6th **Date of Performance:** 21/01/2025
Subject Name: AP LAB-II **Subject Code:** 22CSP-351

1. Problem Statement : Sort Colors

Given an array nums with n objects colored red, white, or blue, sort them in-place so that objects of the same color are adjacent, with the colors in the order red, white, and blue. We will use the integers 0, 1, and 2 to represent the color red, white, and blue, respectively. You must solve this problem without using the library's sort function.

Example 1:

Input: nums = [2,0,2,1,1,0] Output: [0,0,1,1,2,2]

Example 2:

Input: nums = [2,0,1] Output: [0,1,2]

Constraints:

n == nums.length 1 <= n <= 300 nums[i] is either 0, 1, or 2.

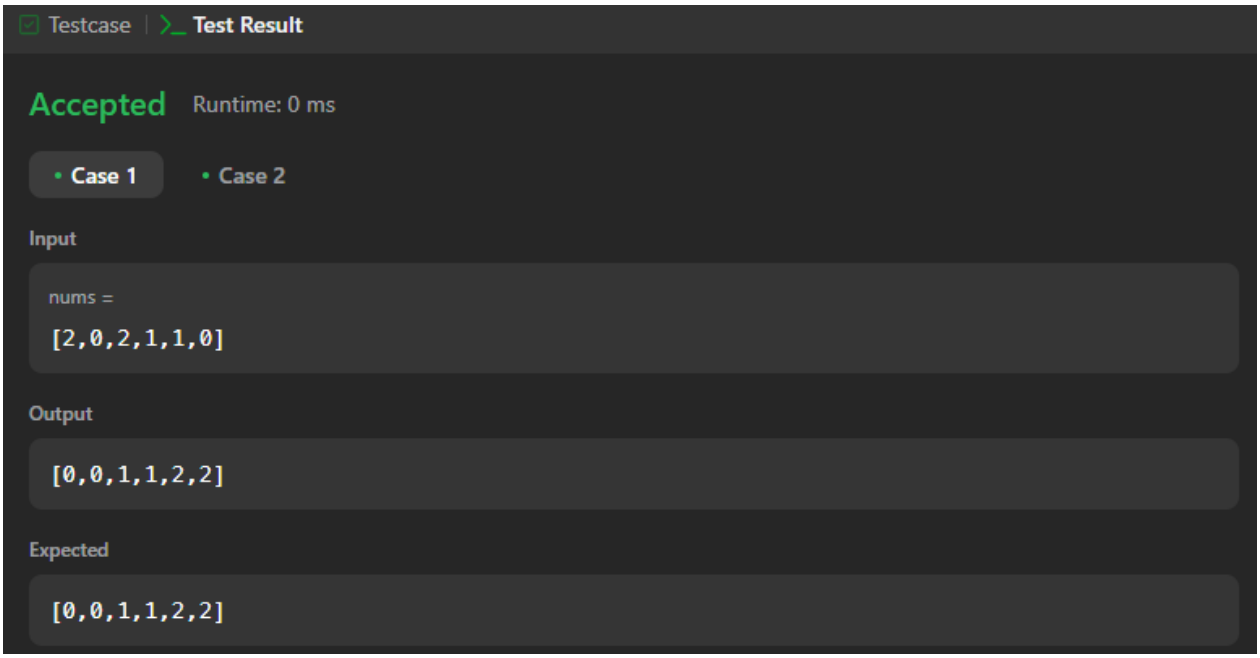
Follow up: Could you come up with a one-pass algorithm using only constant extra space?

Implementation/Code:

```
class Solution {
public:
    void sortColors(vector<int>& nums) {
        unordered_map<int, int> count = {{0, 0}, {1, 0}, {2, 0}};

        for (int num : nums) {
            count[num]++;
        }

        int idx = 0;
        for (int color = 0; color < 3; color++) {
```

```
            int freq = count[color];
            for (int j = 0; j < freq; j++) {
                nums[idx] = color;
                idx++;
            }
        }
    }
};
```

Output:



- **Time Complexity**: O(n)
- **Space Complexity**: O(1)

2. Problem Statement: Kth Largest Element in an Array

Given an integer array nums and an integer k, return the kth largest element in the array. Note that it is the kth largest element in the sorted order, not the kth distinct element. Can you solve it without sorting?

Example 1:

Input: nums = [3,2,1,5,6,4], k = 2 Output: 5

Example 2:

Input: nums = [3,2,3,1,2,4,5,5,6], k = 4 Output: 4

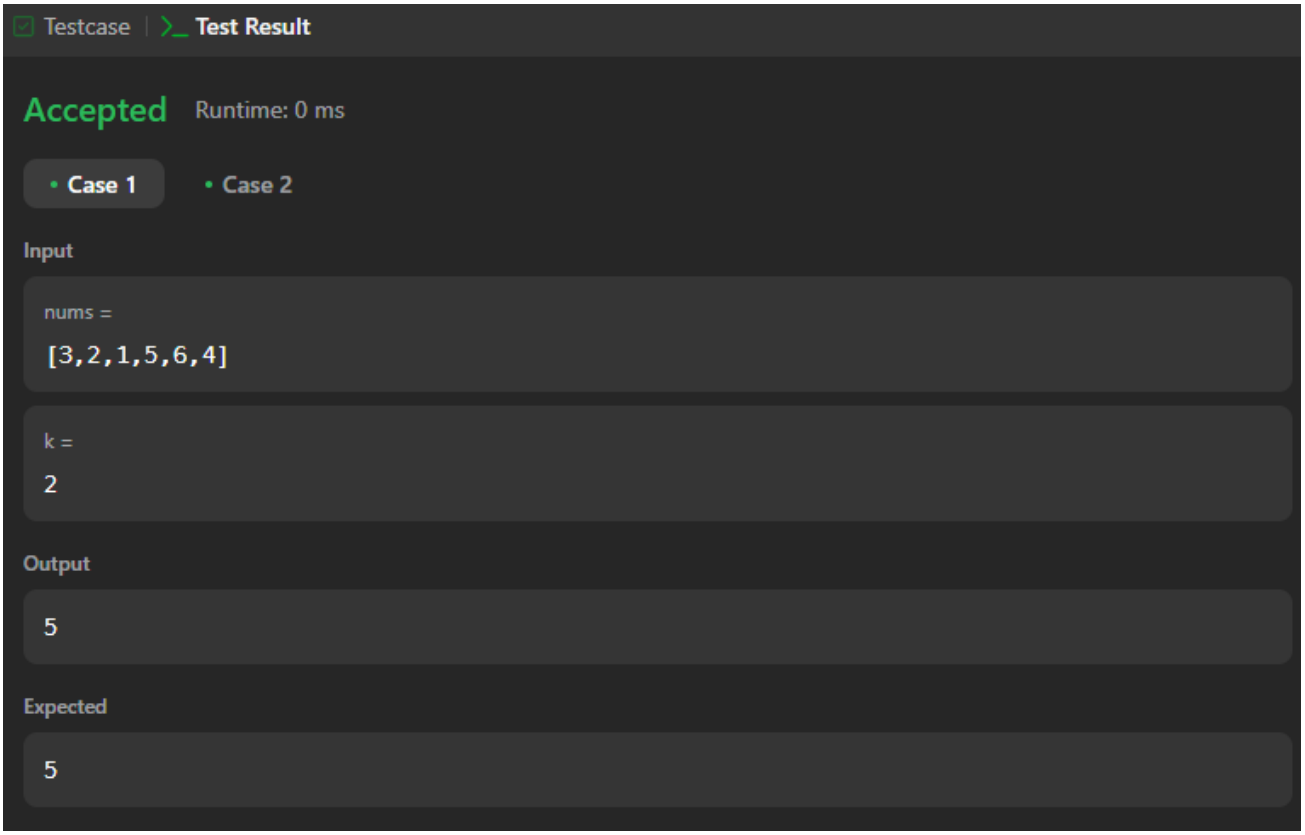
Constraints:

1 <= k <= nums.length <= 105 -104 <= nums[i] <= 104

Implementation/Code:

```
#include <vector>
#include <queue>

using namespace std;

class Solution {
public:
    int findKthLargest(vector<int>& nums, int k) {
        priority_queue<int, vector<int>, greater<int>> minHeap;

        for (int num : nums) {
            minHeap.push(num);
            if (minHeap.size() > k) {
                minHeap.pop();
            }
        }

        return minHeap.top();
    }
};
```

Output:



- **Time Complexity**: O(*nlogn*)
- **Space Complexity**: O(*sort*)

Learning Outcomes:

Problem 1: Sort Colors

1. **Understanding the Three-Way Partitioning** – Learn how to efficiently categorize elements into three groups using a single-pass algorithm.
2. **In-Place Sorting** – Gain experience in sorting an array without using extra space.
3. **Two-Pointer Technique** – Understand the use of multiple pointers to optimize sorting problems.
4. **Time Complexity Optimization** – Learn how to achieve an optimal **O(n) time complexity** instead of the naive **O(n log n)** sorting approach.

Problem 2: Kth Largest Element in an Array

1. **Selection Algorithms** – Learn about QuickSelect, a variant of QuickSort, to efficiently find the kth largest element.

2. **Partitioning Strategies** – Understand how to divide an array into smaller segments to reduce search space.
3. **Heap Data Structure (Alternative Approach)** – Learn how to use Min-Heap or Max-Heap to solve selection problems in **O(n log k) time**.
4. **Average Case Optimization** – Gain insights into reducing time complexity to **O(n) average time** instead of sorting in **O(n log n)**.