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BRANCH-BE-CSE

SECTION/GROUP-IOT-638-A

SEMESTER-6

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SUBJECT NAME-AP-LAB II

SUBJECT CODE-22CSP-351

ASSIGNMENT

PROBLEM 1: 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?

2.CODE

```
#include <iostream>
```

```
#include <vector>
```

```
using namespace std;
```

```
class Solution {
```

```
public:
```

```
    void sortColors(vector<int>& nums) {
```

```

int low = 0, mid = 0, high = nums.size() - 1;
while (mid <= high) {
    if (nums[mid] == 0) {
        swap(nums[low], nums[mid]);
        low++;
        mid++;
    } else if (nums[mid] == 1) {
        mid++;
    } else { // nums[mid] == 2
        swap(nums[mid], nums[high]);
        high--;
    }
}
};

```

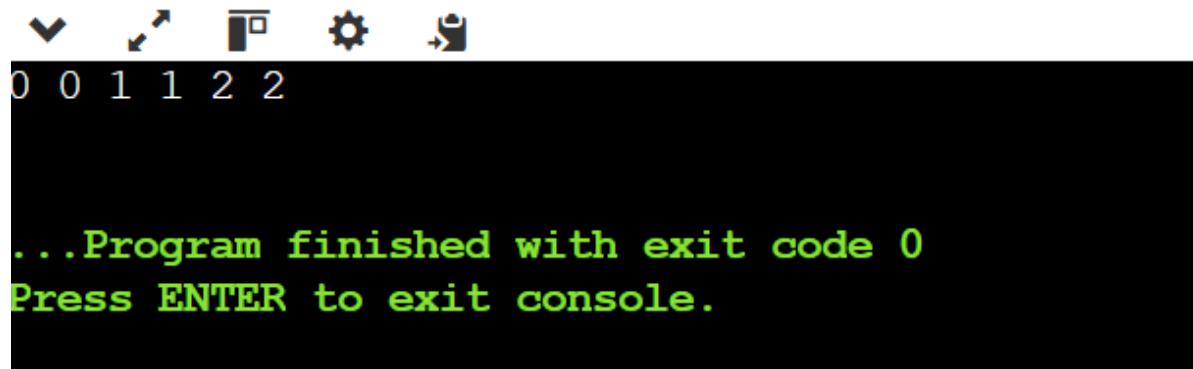
```

int main() {
    vector<int> nums = {2, 0, 2, 1, 1, 0};
    Solution sol;
    sol.sortColors(nums);

    for (int num : nums) {
        cout << num << " ";
    }
    cout << endl;
    return 0;
}

```

OUTPUT:



```
0 0 1 1 2 2

...Program finished with exit code 0
Press ENTER to exit console.
```

LEARNING OUTCOMES:

1. **Understanding the Dutch National Flag Algorithm** – Learned how to efficiently sort an array containing three distinct elements (0, 1, 2) in **one pass ($O(n)$)** using a **three-pointer approach**.
2. **In-Place Sorting Without Extra Space** – Developed skills to sort the array **without using extra memory ($O(1)$)**, making the solution space-efficient.
3. **Efficient Array Manipulation with Swap Operations** – Gained hands-on experience in swapping elements strategically using **low, mid, and high pointers** to ensure correct ordering.
4. **Optimizing Sorting Without Using Built-in Functions** – Learned how to manually implement sorting logic **without relying on `sort()`**, which is useful for interviews and competitive programming.

PROBLEM 2: Kth Largest Element in an Array

Given an integer array `nums` and an integer `k`, return the `k`th largest element in the array. Note that it is the `k`th largest element in the sorted order, not the `k`th 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

CODE:

```
#include <iostream>
#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;

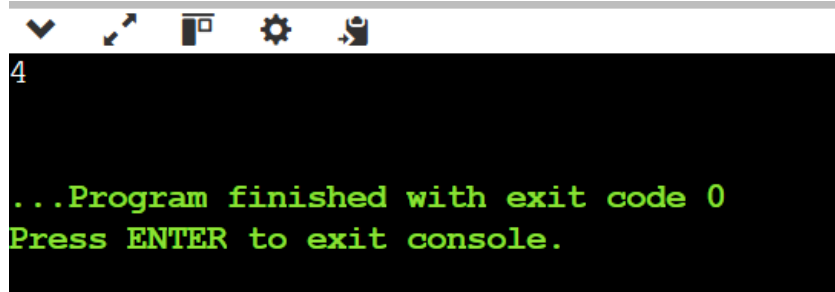
        for (int num : nums) {
            minHeap.push(num);
            if (minHeap.size() > k) {
                minHeap.pop(); // Remove smallest element to maintain size k
            }
        }

        return minHeap.top(); // The root of the min-heap is the kth largest element
    }
};

int main() {
    vector<int> nums = {3, 2, 3, 1, 2, 4, 5, 5, 6};
    int k = 4;
    Solution sol;
    cout << sol.findKthLargest(nums, k) << endl; // Output: 4
    return 0;
}
```

```
}
```

OUTPUT:

A screenshot of a console window with a dark background. At the top, there is a toolbar with icons for a dropdown menu, a cursor, a window, a gear, and a document. Below the toolbar, the number '4' is displayed in the top-left corner. The main text in the console is green and reads: "...Program finished with exit code 0" followed by "Press ENTER to exit console." on the next line.

```
4  
  
...Program finished with exit code 0  
Press ENTER to exit console.
```

LEARNING OUTCOMES:

- 1. Understanding Heap Data Structure** – Learned how to use a Min-Heap (Priority Queue) to efficiently find the k-th largest element in $O(n \log k)$ time complexity.
- 2. Optimized Selection Without Sorting** – Developed the ability to find the k-th largest element without sorting ($O(n \log n)$), using a more efficient approach like Heap or Quickselect ($O(n)$ average).
- 3. Efficient Space Utilization** – Gained experience in solving problems using $O(k)$ extra space for the Min-Heap, making it memory-efficient compared to full sorting.
- 4. Application of Quickselect Algorithm** – Learned how to apply the Quickselect Algorithm ($O(n)$ average case), a variation of QuickSort, to efficiently find the k-th largest element in an unordered list.