Experiment - 4(A)

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Subject Name: Advanced Programming Lab-2 **Subject Code:** 22CSH-359

1. **Title:** Sorting and Searching (Merge Sorted Array)
https://leetcode.com/problems/merge-sorted-array/

2. **Objective:** To merge two sorted arrays nums1 and nums2 into one sorted array, while ensuring that the result is stored in nums1. The algorithm should be efficient and merge the arrays in-place.

3. **Algorithm:**
   - Start with three pointers: `i` for the last element of `nums1` (index `m-1`), `j` for the last element of `nums2` (index `n-1`), and `k` for the last position in `nums1` (index `m+n-1`).
   - Compare the elements at `nums1[i]` and `nums2[j]`. Place the larger of the two at `nums1[k]`, and decrement `k`.
   - If `nums1[i]` is greater, move `i` left. If `nums2[j]` is greater, move `j` left.
   - If any elements are left in `nums2`, copy them to `nums1` (since `nums1` already contains the first `m` elements in sorted order).
   - Continue the process until all elements from both arrays are merged.

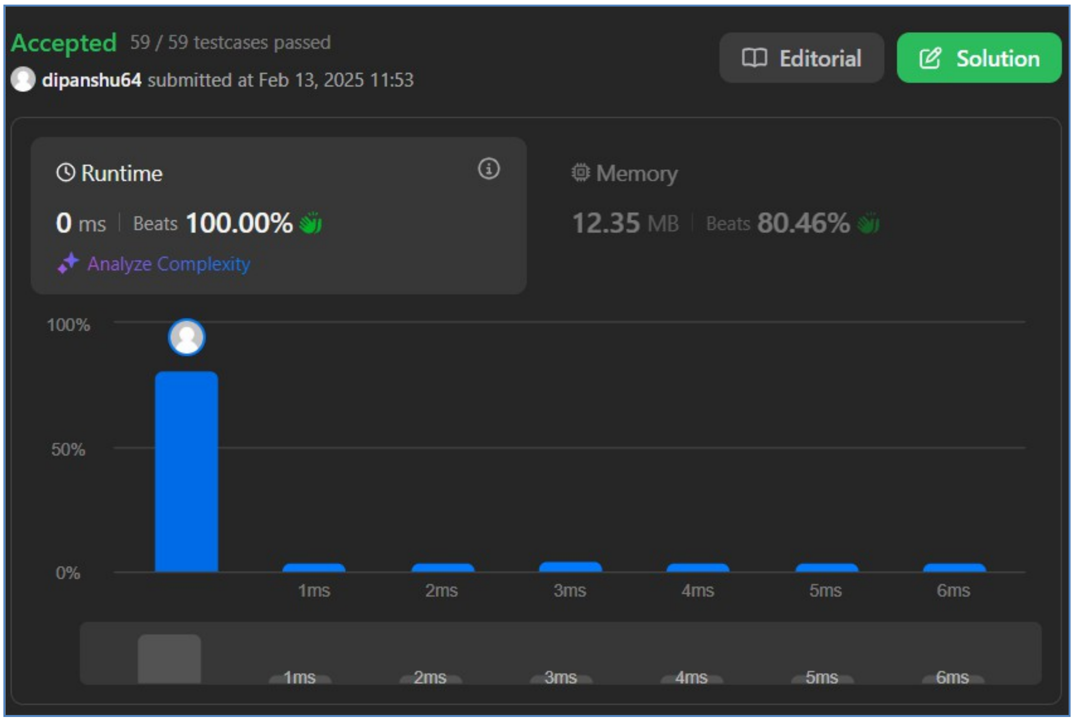
4. **Implementation/Code:**

```
class Solution:
def merge(self, nums1, m, nums2, n):
    # Start from the end of both arrays
    i, j, k = m - 1, n - 1, m + n - 1

    # Merge in reverse order
    while i >= 0 and j >= 0:
        if nums1[i] > nums2[j]:
            nums1[k] = nums1[i]
            i -= 1
        else:
            nums1[k] = nums2[j]
            j -= 1
        k -= 1
```

```
    # If nums2 is not fully traversed, copy the remaining elements
    while j >= 0:
        nums1[k] = nums2[j]
        j -= 1
        k -= 1
```

5. **Output:**



6. **Time Complexity:** O(m+n)

7. **Space Complexity:** O(1)

8. **Learning Outcomes:**

- **Array Manipulation**: Understanding how to manipulate arrays in-place.
- **Two Pointer Technique**: Using multiple pointers to traverse arrays efficiently and merge them.
- **In-place Sorting**: Learning how to merge sorted arrays without extra space.
- **Optimization**: Achieving linear time complexity by processing the arrays from the end, avoiding unnecessary moves.

Experiment 4(B)

1. **Title:** First Bad Colors (https://leetcode.com/problems/first-bad-version/)

2. **Objective:** The task is to find the first bad version in a series of product versions, where all versions after the first bad version are also bad. You should minimize the number of calls to the isBadVersion(version) API.

3. **Algorithm:**
   - Initialize two pointers `left` as 1 and `right` as `n`.
   - Perform a binary search:
     - While `left` is less than `right`, calculate the mid-point `mid = (left + right) // 2`.
     - If `isBadVersion(mid)` is `True`, then the first bad version is at `mid` or to the left of it, so update `right = mid`.
     - If `isBadVersion(mid)` is `False`, then the first bad version must be to the right, so update `left = mid + 1`.
   - When the loop terminates, `left` will point to the first bad version.

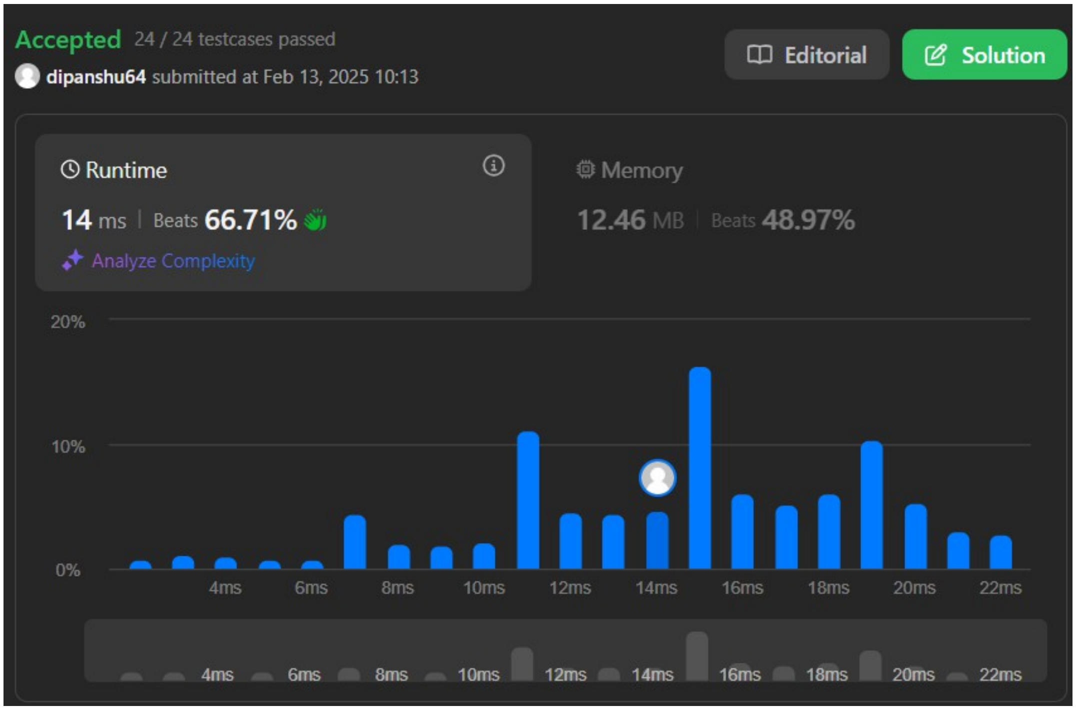
4. **Implementation/Code:**

```
class Solution:
    def firstBadVersion(self, n):
        left, right = 1, n

        while left < right:
            mid = left + (right - left) // 2
            if isBadVersion(mid):
                right = mid  # Potential first bad version
            else:
                left = mid + 1  # Bad version must be on the right

        return left
```

6. Output:



8. Time Complexity: O(log n) **9. Space Complexity:** O(1)

9. Learning Outcomes:

1. **Binary Search**: Understanding and applying the binary search algorithm to reduce the number of checks (calls to isBadVersion).

2. **Optimization**: Minimizing the number of calls to an external API, which is a key performance concern in real-world applications.

3. **Problem Solving**: Effectively narrowing down the range for the first bad version using a divide-and-conquer strategy.

Experiment 4(C)

1. **Title:** Sort Colors (https://leetcode.com/problems/sort-colors/)

2. **Objective:** To sort an array containing three distinct values (0, 1, 2) in place, where 0 represents red, 1 represents white, and 2 represents blue. The array should be sorted in such a way that all 0s come first, followed by all 1s, and then all 2s.

4. **Algorithm:**

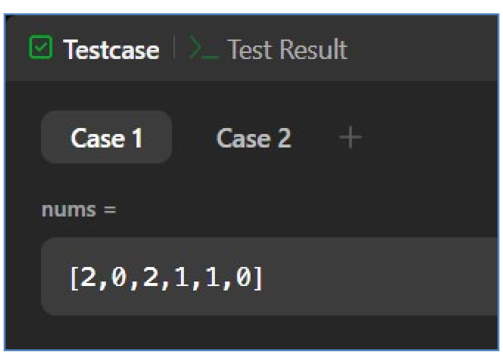
- Initialize three pointers: `low` (starting at the beginning of the array), `mid` (also starting at the beginning), and `high` (starting at the end of the array).
- Traverse the array using the `mid` pointer:
  - If `nums[mid]` is 0, swap it with `nums[low]` and increment both `low` and `mid`.
  - If `nums[mid]` is 1, just increment `mid`.
  - If `nums[mid]` is 2, swap it with `nums[high]` and decrement `high`.
- Continue this process until `mid` exceeds `high`.

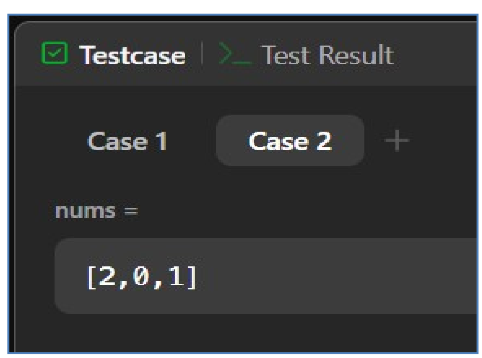
5. **Implementation/Code:**

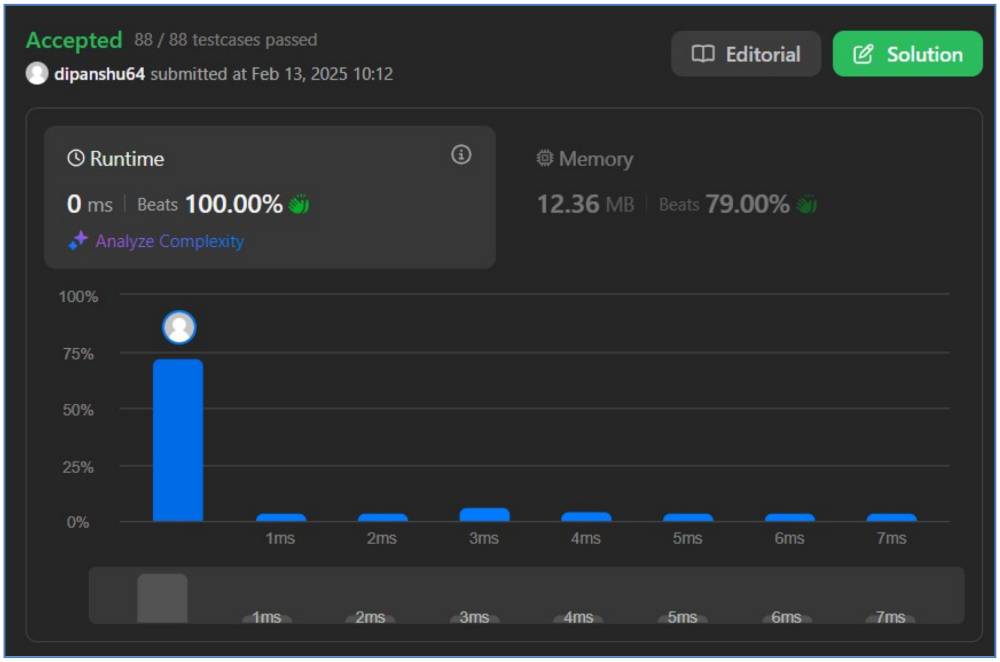
```
class Solution:
    def sortColors(self, nums):
        low, mid, high = 0, 0, len(nums) - 1

        while mid <= high:
            if nums[mid] == 0:
                nums[low], nums[mid] = nums[mid], nums[low]
                low += 1
                mid += 1
            elif nums[mid] == 1:
                mid += 1
            else:
                nums[mid], nums[high] = nums[high], nums[mid]
                high -= 1
```

6. **Output:**







8. <u>Time Complexity:</u> O(N)

9. <u>Space Complexity:</u> O(1)

10. <u>Learning Outcomes:</u>

1. **Three-way Partitioning**: Understanding how to partition an array into three groups based on a specific condition (here, 0, 1, 2).
2. **In-place Sorting**: Sorting without using extra space for another array.
3. **Two Pointer Technique**: Efficient use of multiple pointers (low, mid, high) to traverse the array in a single pass.
4. **Optimization**: Solving the problem in linear time (O(n)) and constant space (O(1)).