Arrays, Strings & Linked Lists Lecture 2

Sunday, 21 July 2024 3:02 PM

2-Sum Problem

$a = [2, 7, 11, 15]$ $k = 9$

$a = [-1, 3, -2, -6, 10, 5, -3]$ $k = 3$

0, 1, 2, 3, 4, 5, 6

$[-2, 5] \leftarrow$ values

$[2, 5] \leftarrow$ Index

$\boxed{O(n\log n)}$

sorted

$a = [-6, -3, -2, -1, 3, 5, 10]$

$O(n) \longrightarrow$ i i i j

$i \to j$

Sum

move left ↑

move right ↓

left (i) smallest → largest

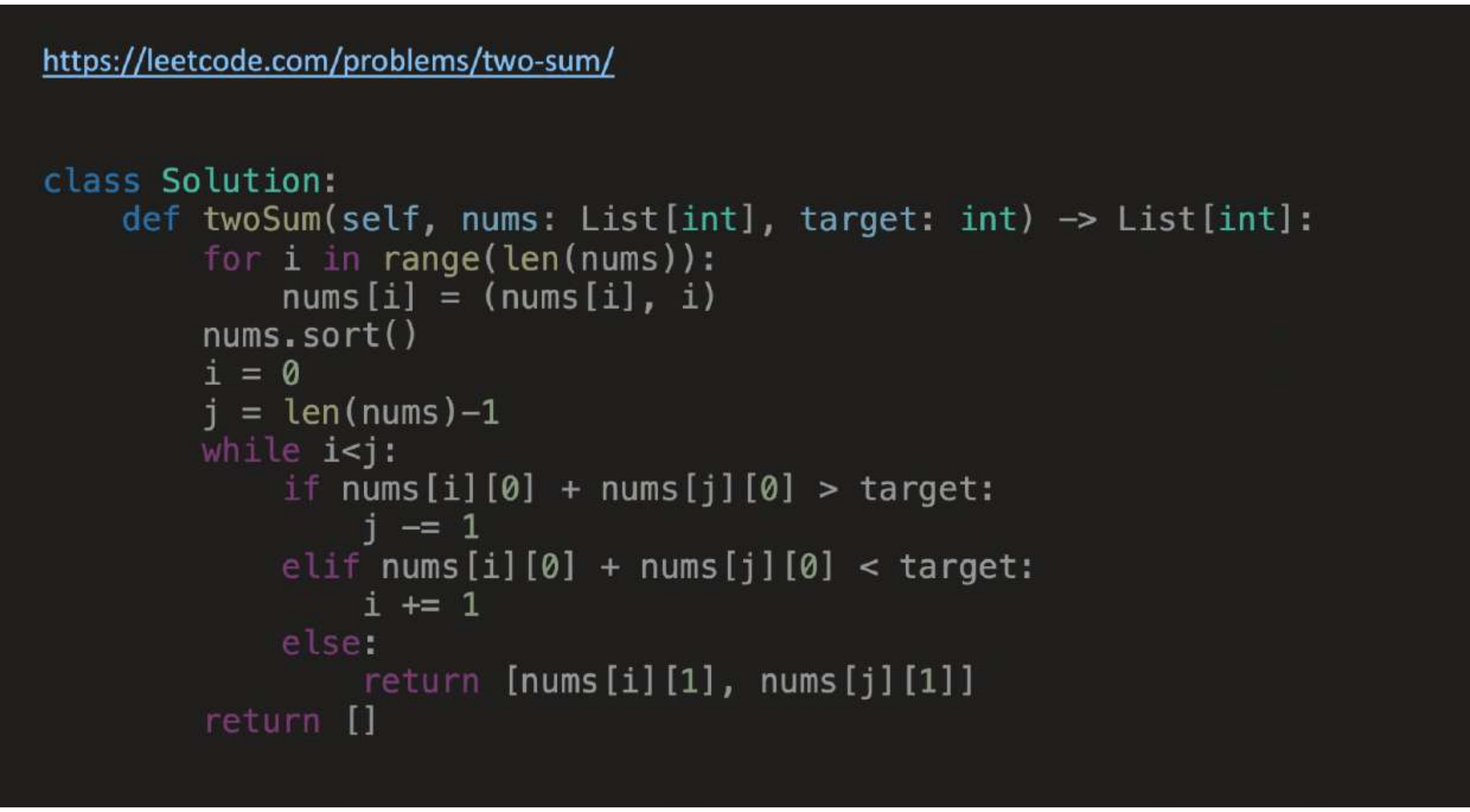
right (j) largest → smallest.

$-6+10 = 4$

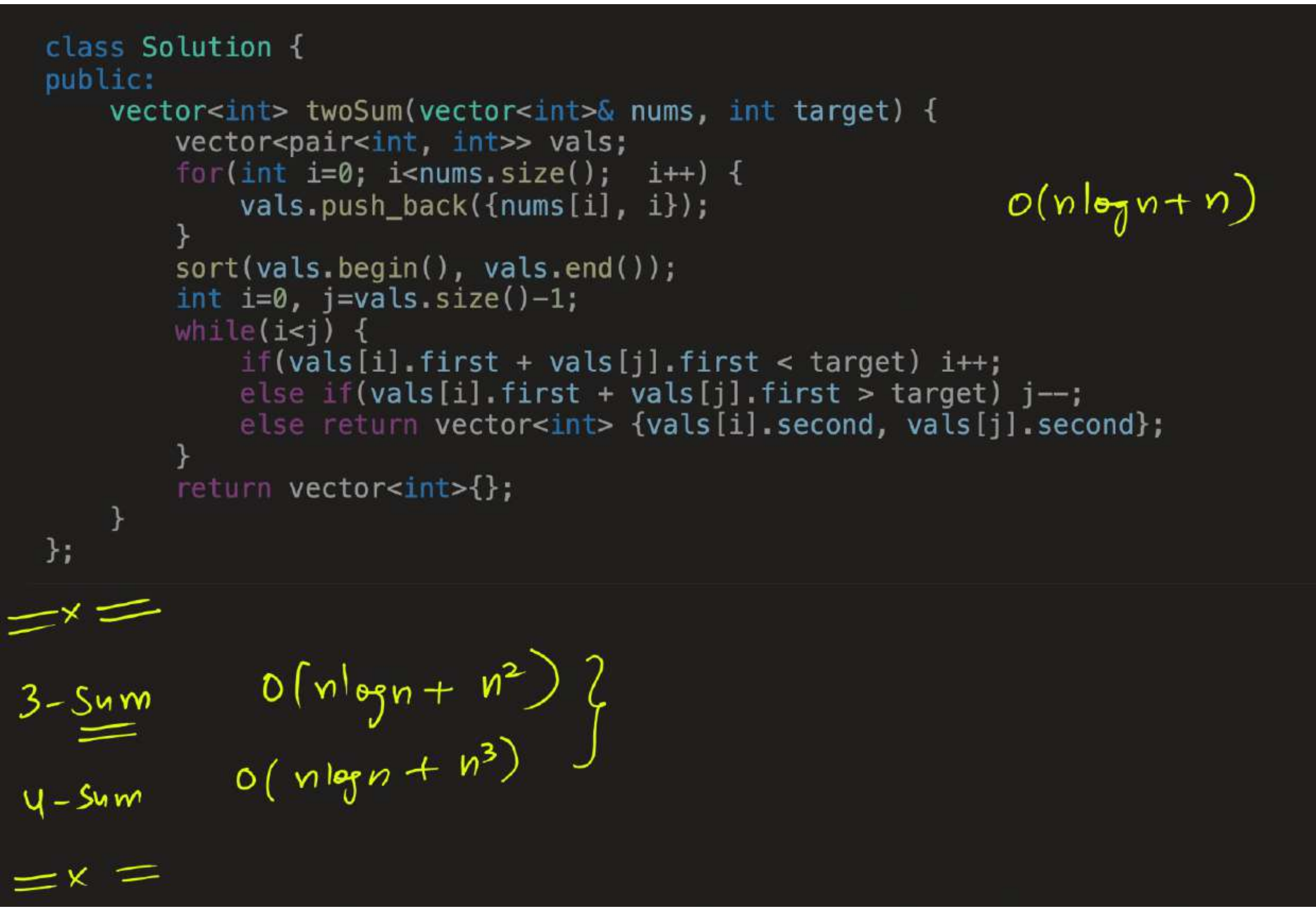
$-6+5 = -1$

$-3+5 = 2$

$-2+5 = \boxed{3}$


https://leetcode.com/problems/two-sum/

```python
class Solution:
    def twoSum(self, nums: List[int], target: int) -> List[int]:
        for i in range(len(nums)):
            nums[i] = (nums[i], i)
        nums.sort()
        i = 0
        j = len(nums)-1
        while i<j:
            if nums[i][0] + nums[j][0] > target:
                j -= 1
            elif nums[i][0] + nums[j][0] < target:
                i += 1
            else:
                return [nums[i][1], nums[j][1]]
        return []
```



```cpp
class Solution {
public:
    vector<int> twoSum(vector<int>& nums, int target) {
        vector<pair<int, int>> vals;
        for(int i=0; i<nums.size();  i++) {
            vals.push_back({nums[i], i});
        }
        sort(vals.begin(), vals.end());
        int i=0, j=vals.size()-1;
        while(i<j) {
            if(vals[i].first + vals[j].first < target) i++;
            else if(vals[i].first + vals[j].first > target) j--;
            else return vector<int> {vals[i].second, vals[j].second};
        }
        return vector<int>{};
    }
};
```

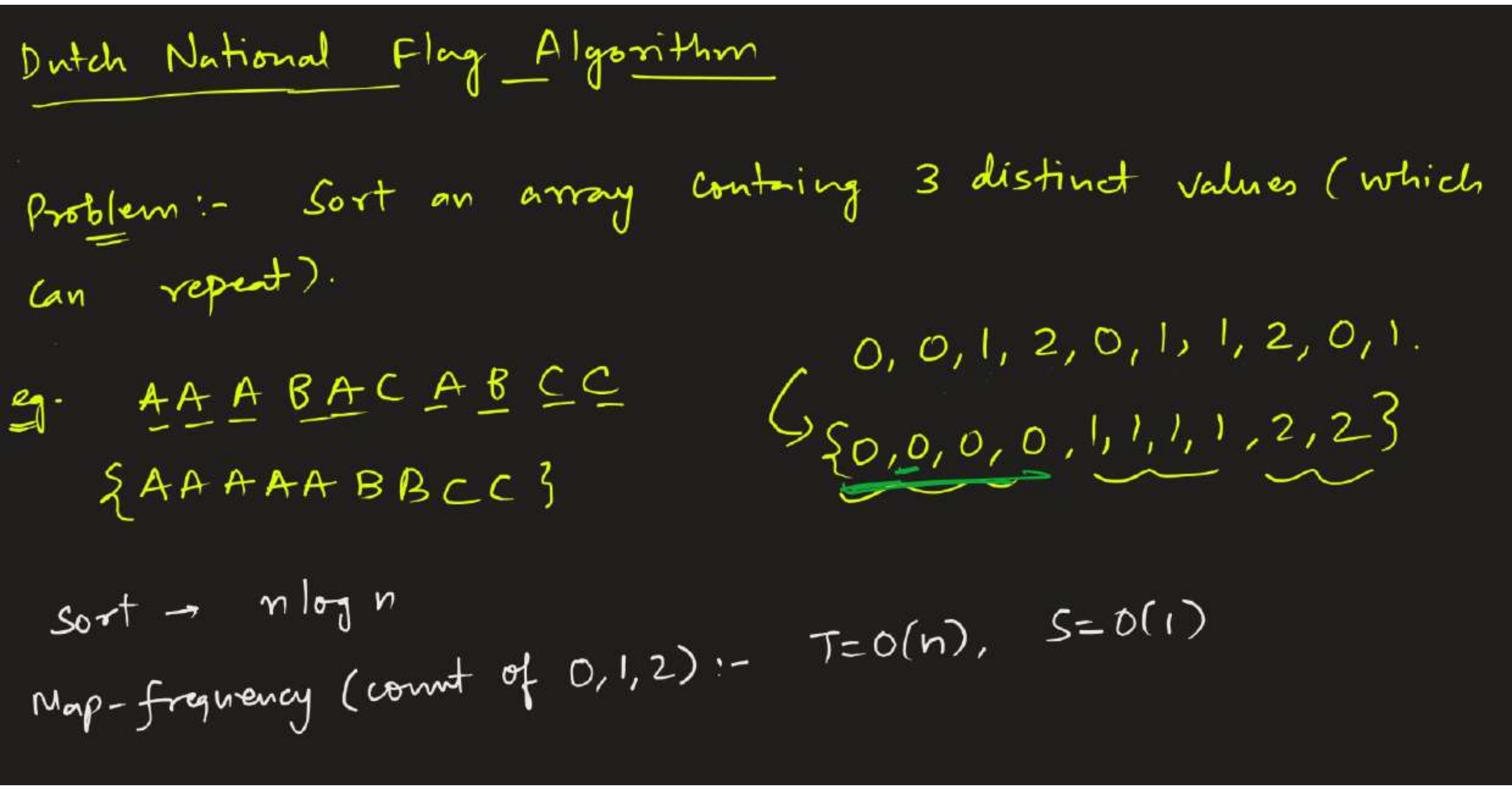
$O(n\log n + n)$

=x=

3-Sum $O(n\log n + n^2)$

4-Sum $O(n\log n + n^3)$

=x=



Dutch National Flag Algorithm

Problem :- Sort an array containing 3 distinct values (which can repeat).

eg. A A A B A C A B C C

{A A A A A B B C C}

0, 0, 1, 2, 0, 1, 1, 2, 0, 1.

$\hookrightarrow \{\underbrace{0, 0, 0, 0}, \underbrace{1, 1, 1, 1}, \underbrace{2, 2}\}$

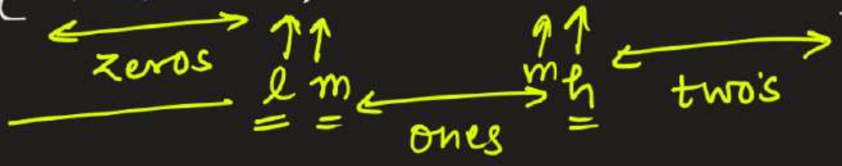
sort → n log n

Map-frequency (count of 0,1,2) :- T=O(n), S=O(1)

Optimal :-

{ 2, 1, 0, 0, 1, 1, 0, 2, 0, 1, 2, 1 }

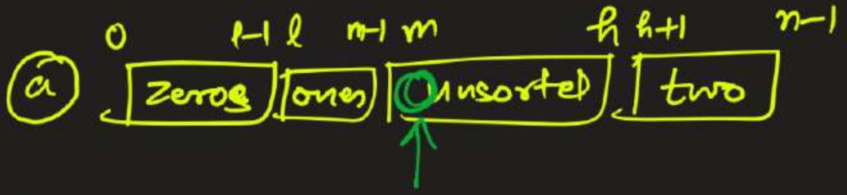
{ 0, 0, 0, 0, 1, 1, 1, 1, 1, 2, 2, 2 }

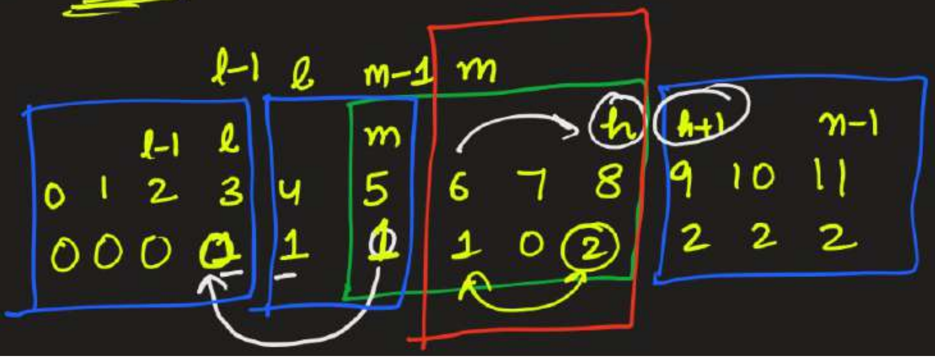


2, 1, 0, 0, 1, 1, 0, 2, 0, 1, 2, 1

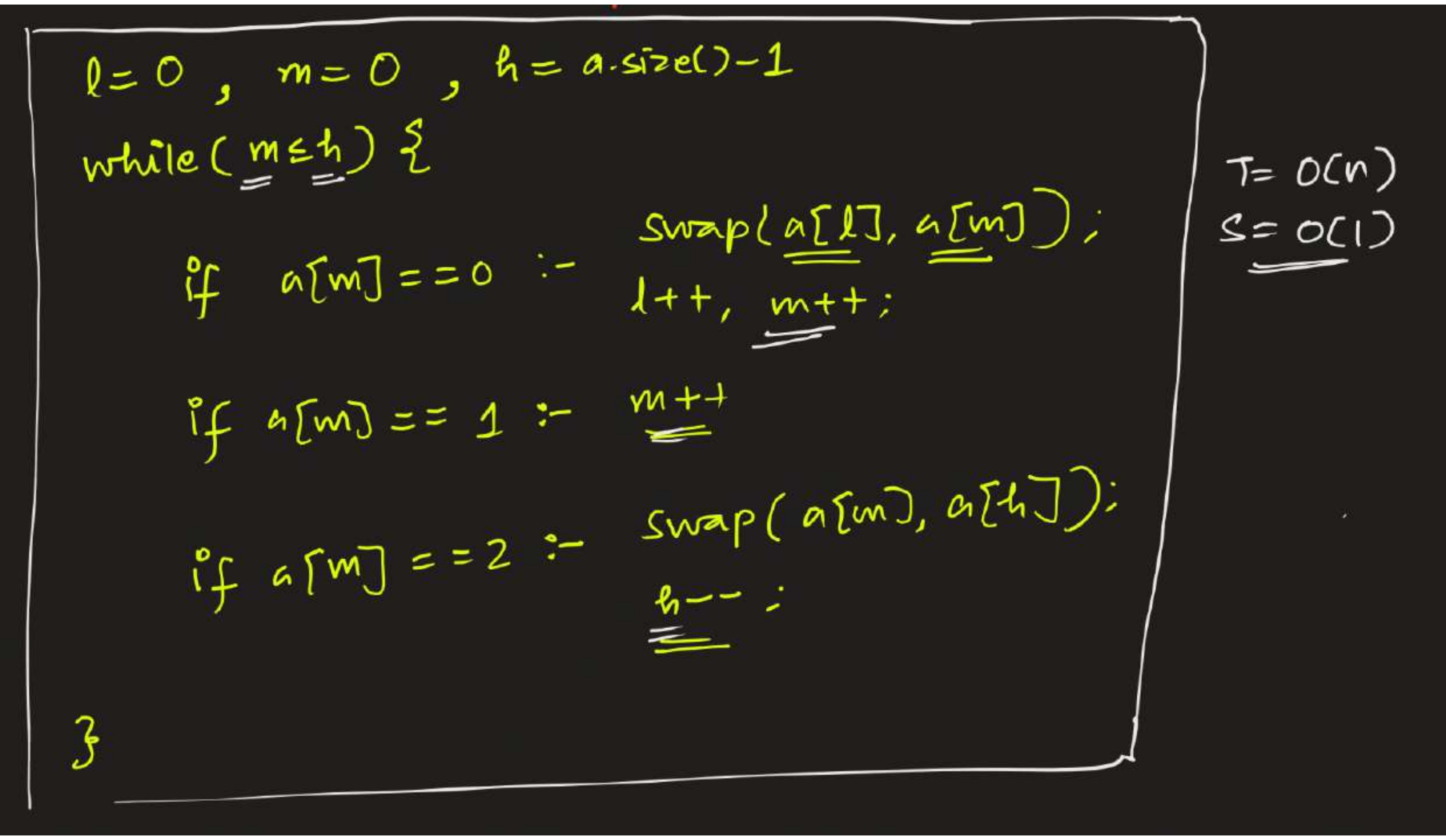
l, m, h :-

* 0 → l-1 all zeros
* l → m-1 all ones
* m → h unsorted array
* h+1 → n-1 all twos



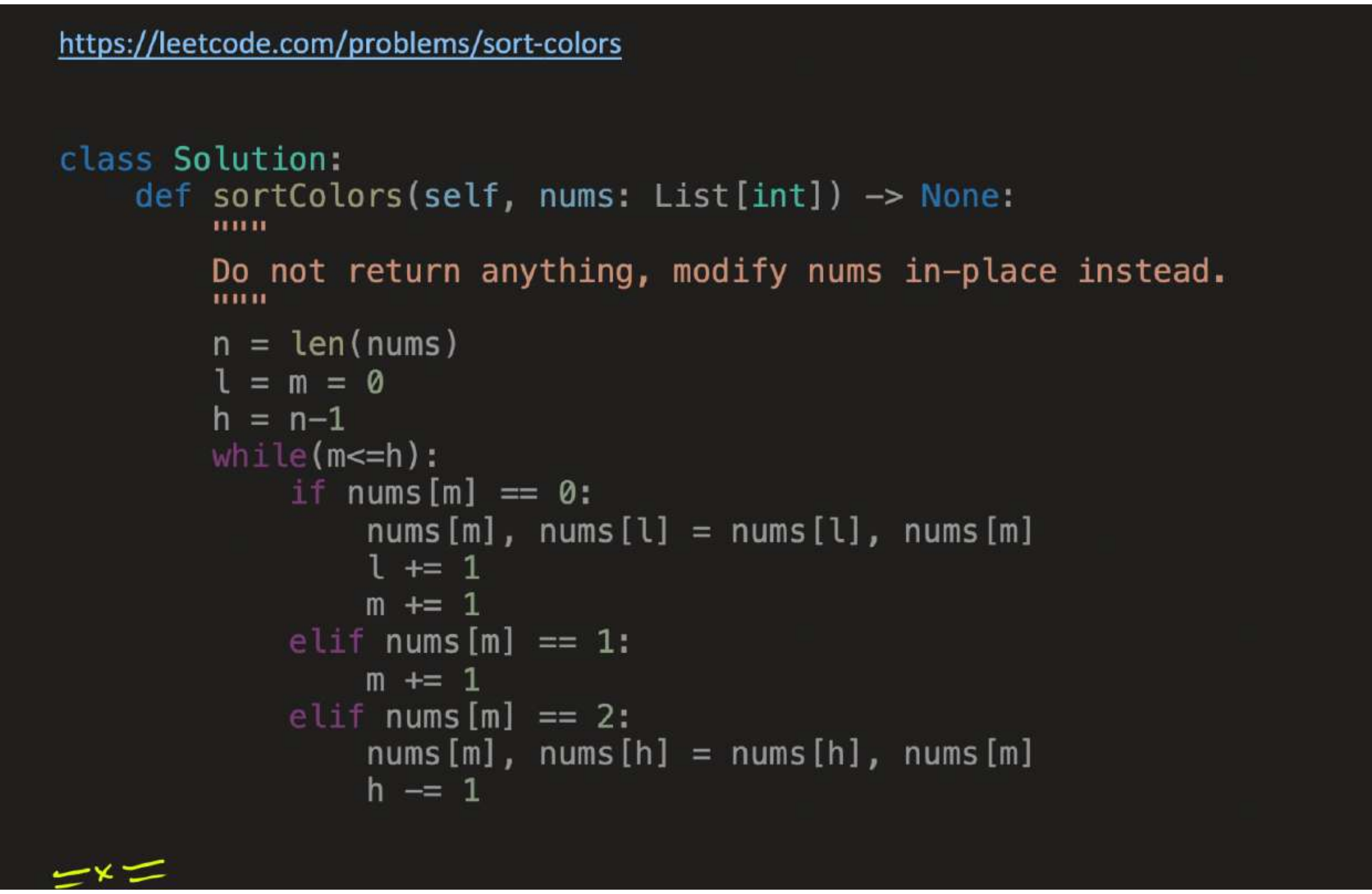


n = 12



```
l = 0 , m = 0 , h = a.size()-1
while ( m ≤ h ) {

    if a[m] == 0 :-   swap( a[l], a[m] );
                      l++, m++;

    if a[m] == 1 :-   m++

    if a[m] == 2 :-   swap( a[m], a[h] );
                      h-- ;

}
```

T = O(n)
S = O(1)



https://leetcode.com/problems/sort-colors

```python
class Solution:
    def sortColors(self, nums: List[int]) -> None:
        """
        Do not return anything, modify nums in-place instead.
        """
        n = len(nums)
        l = m = 0
        h = n-1
        while(m<=h):
            if nums[m] == 0:
                nums[m], nums[l] = nums[l], nums[m]
                l += 1
                m += 1
            elif nums[m] == 1:
                m += 1
            elif nums[m] == 2:
                nums[m], nums[h] = nums[h], nums[m]
                h -= 1
```

=×=

Moore's Voting Algorithm

Problem:- Find the majority element in array
↳ ($> n/2$ times)

eg. 3, 3, 3, 2, 2, 1, 1 there is no majority element.

eg. 3, 3, 1, 3, 2, 1, 3, 3 , 3 is a mjority element.

① Brute :-

$T = O(n^2)$
$S = O(1)$

```
for ( i : arr) {
    c=0
    for( j : arr) {
        if( j ==i)  c++;
    }
    if ( c > n/2)  return i ;
}
```

② un-map<int, int> freq;

```
for (i : arr) {
        freq[i]++;
}
for (i : freq) {
    if (freq[i] > n/2) {
            return i
    }
}
```

$T = O(n)$

$S = O(n)$

③ optimal

$\{\cancel{3}, \cancel{3}, \cancel{1}, \cancel{3}, \cancel{2}, \cancel{1}, \boxed{3}\}$

$\{\cancel{3}, \cancel{3}, \cancel{3}, \cancel{2}, \cancel{2}, \cancel{1}, \boxed{1}\}$

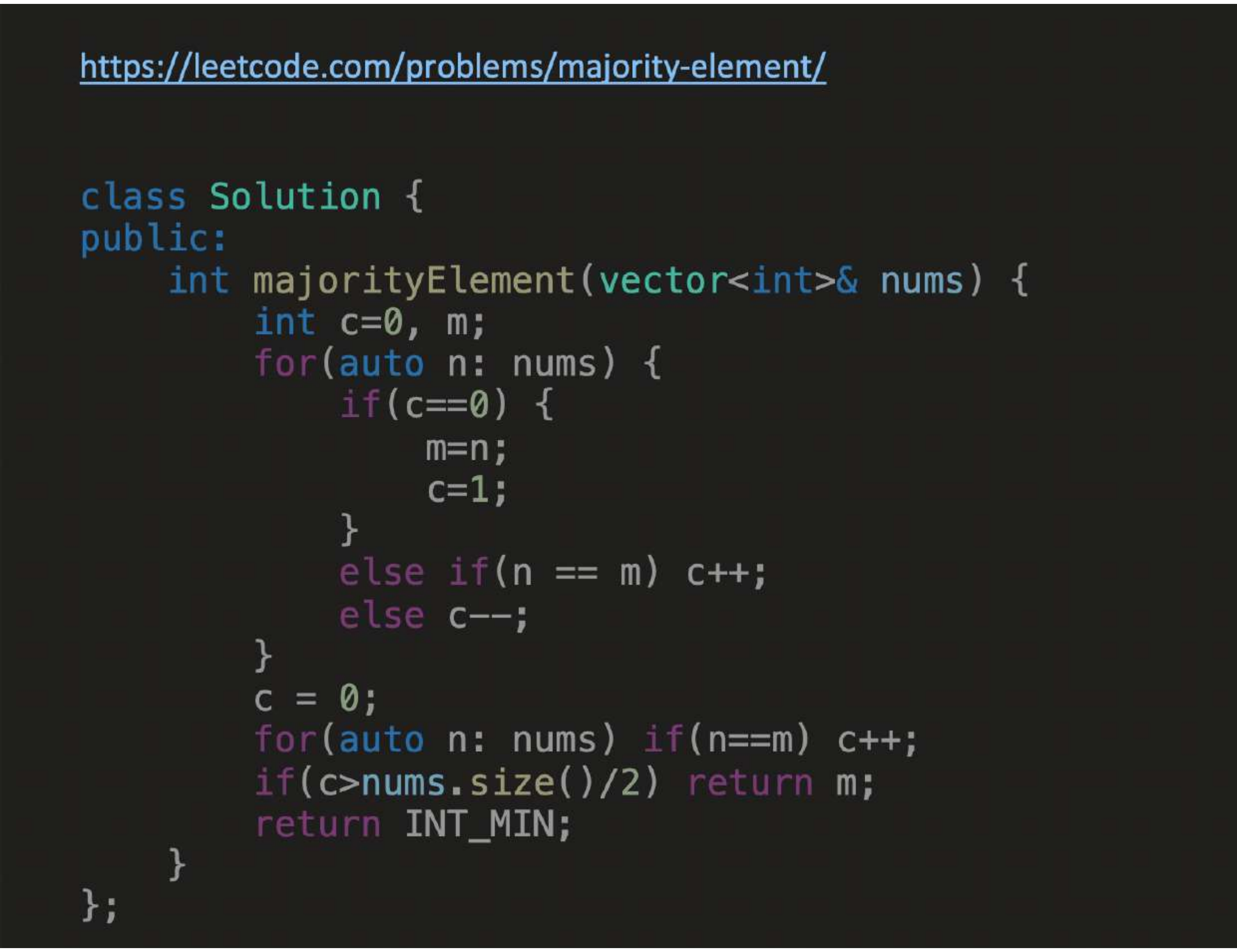
$\{\underset{\uparrow}{\cancel{1}}, \underset{\uparrow}{\cancel{3}}, \underset{\uparrow}{\cancel{2}}, \underset{\uparrow}{\cancel{3}}, \underset{\uparrow}{3}, \underset{\uparrow}{\cancel{3}}, \underset{\uparrow}{\cancel{2}}, \underset{\uparrow}{3}\}$

if all other elements try to the cancel out the majority element, still the majority element will be left.

$c = \cancel{1}\ \cancel{0}\ \cancel{1}\ \cancel{0}\ \cancel{1}\ \cancel{2}\ \cancel{1}\ \boxed{2}$

$\underline{m} = \cancel{1}\ \cancel{2}\ \boxed{3}$

if a majority element exists, it has to be $\boxed{m}$



https://leetcode.com/problems/majority-element/

```
class Solution {
public:
    int majorityElement(vector<int>& nums) {
        int c=0, m;
        for(auto n: nums) {
            if(c==0) {
                m=n;
                c=1;
            }
            else if(n == m) c++;
            else c--;
        }
        c = 0;
        for(auto n: nums) if(n==m) c++;
        if(c>nums.size()/2) return m;
        return INT_MIN;
    }
};
```

Maximum Subarray Sum

[Kadane's Algorithm]

Problem:- Find the subarray with maximum sum.

eg: $[-2, 1, -3, \boxed{4, -1, 2, 1} -5, 4]$

sum = 6
(maximum)

(i) Brute force :-

check every subarray.
Find the sum
maxSum= max(mS, sum)

```
mSum = 0;
for (i : 0 → n-1) {
        for (j : i → n-1) {
            sum = 0;
            for (l : i → j) {
                Sum += arr[l];
            }
            mSum= Max(mSum, sum);

        }
}
return mSum;
```

1, 1, 2, 1, 3, 2, 1

T= $O(n^3)$ ✓

S= O(1)

https://leetcode.com/problems/maximum-subarray/

```
class Solution {
public:
    int maxSubArray(vector<int>& nums) {
        int ms = INT_MIN;
        for(int i=0; i<nums.size(); i++) {
            int s=0;
            for(int j=i; j<nums.size(); j++) {
                s+=nums[j];
                ms=max(ms, s);
            }
        }
        return ms;
    }
};
```

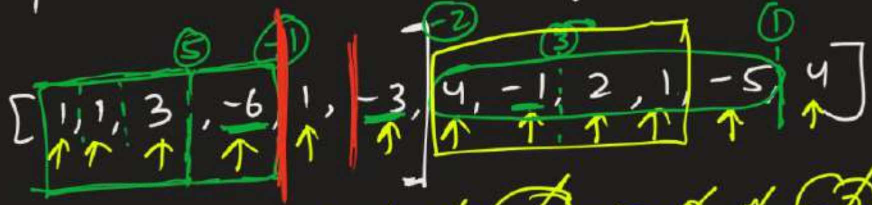
$T = O(n^2)$

$S = O(1)$

— x —

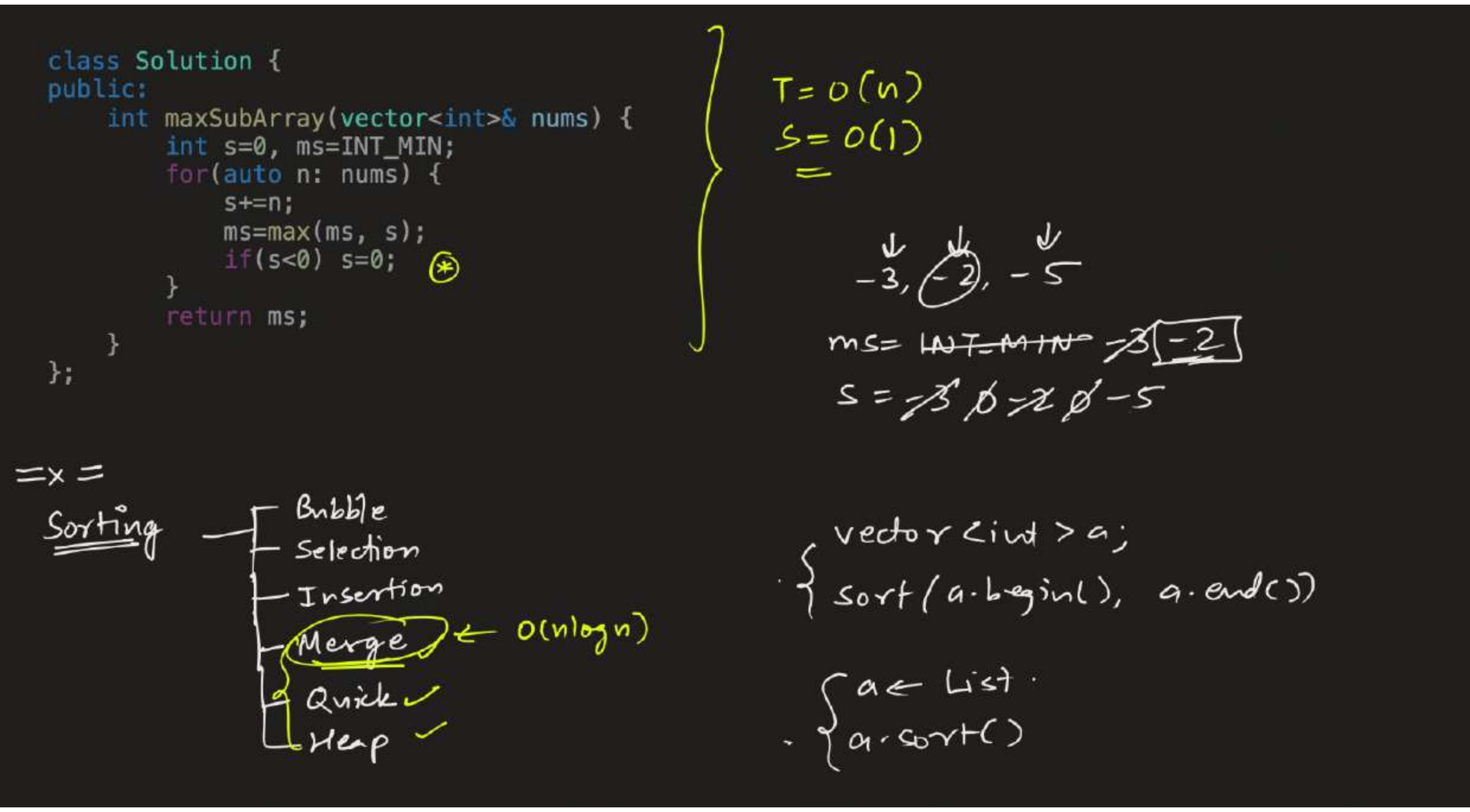
(iii) optimal (Kadane's Algorithm)

eg: [1, 1, 3, -6, 1, -3, 4, -1, 2, 1, -5, 4]



SumTillNow = $\cancel{1}\ \cancel{2}\ \cancel{5}\ \cancel{-1} \rightarrow \cancel{0}\ \cancel{1}\ \cancel{-2} \rightarrow \cancel{0}\ \cancel{4}\ \cancel{3}\ \cancel{5}\ \cancel{6}\ \cancel{1}\ 5$

maxSum = $\cancel{1}\ \cancel{2}\ \cancel{5}\ \boxed{6}$



```cpp
class Solution {
public:
    int maxSubArray(vector<int>& nums) {
        int s=0, ms=INT_MIN;
        for(auto n: nums) {
            s+=n;
            ms=max(ms, s);
            if(s<0) s=0;    (*)
        }
        return ms;
    }
};
```

$T = O(n)$

$S = O(1)$

$-3, -2, -5$

ms = ~~INT_MIN~~ ~~-3~~ $\boxed{-2}$

s = ~~-3~~ ~~0~~ ~~-2~~ ~~0~~ -5

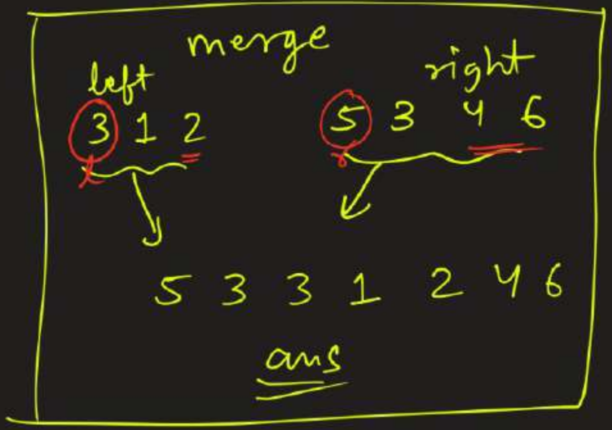
=x=

Sorting
- Bubble
- Selection
- Insertion
- Merge ← O(nlogn)
- Quick ✓
- Heap ✓

```
vector<int> a;
sort(a.begin(), a.end())
```

```
a ← List
a.sort()
```

https://www.geeksforgeeks.org/problems/sort-in-specific-order2422/1

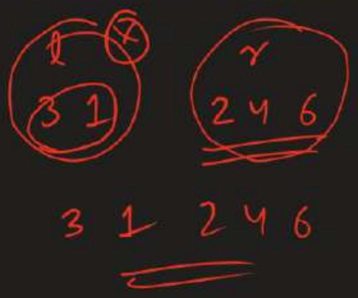


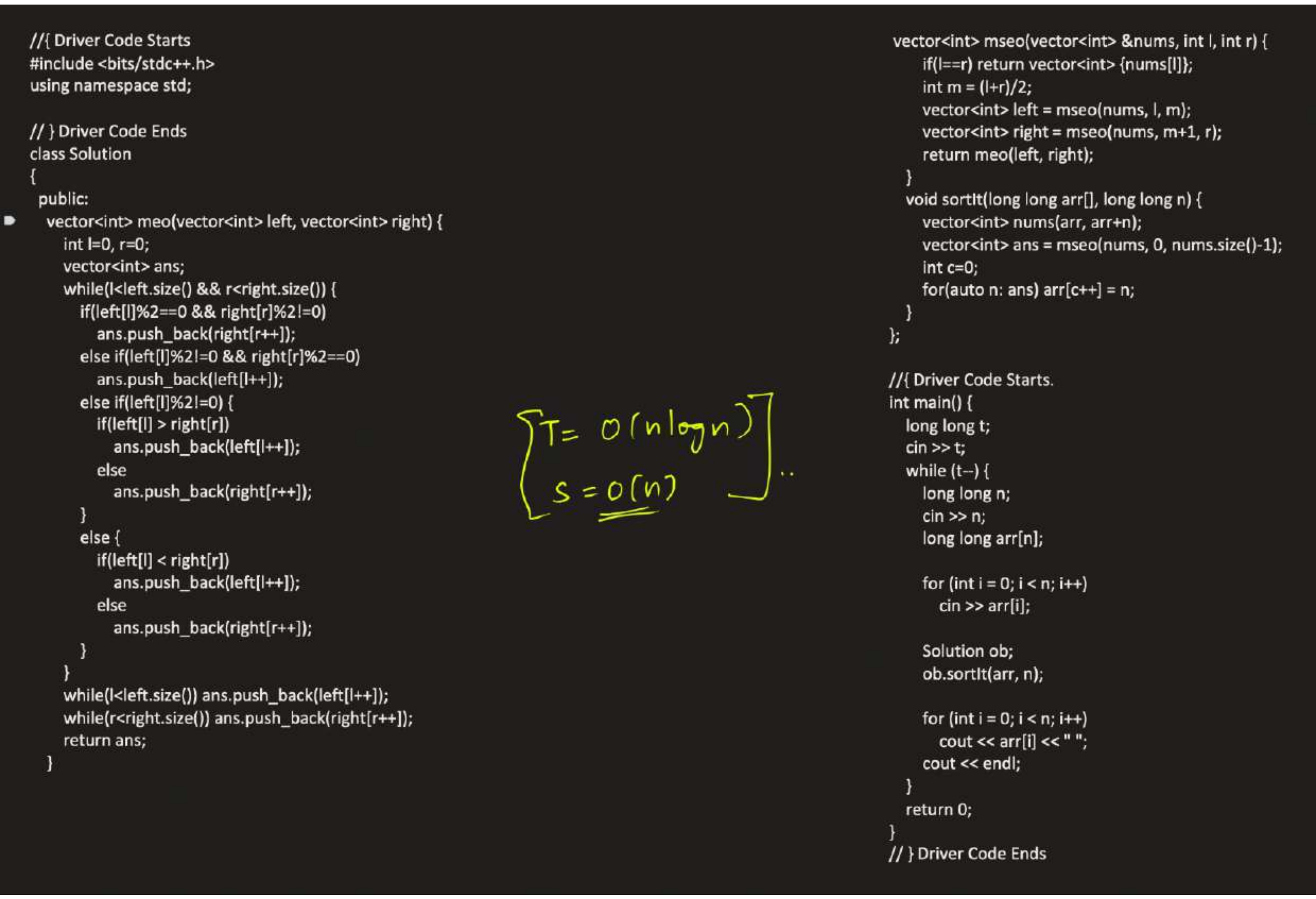
both odd
insert bigger element

one even one odd
insert odd element

both even
insert smaller element

insert all the remaining elements.





```cpp
//{ Driver Code Starts
#include <bits/stdc++.h>
using namespace std;

// } Driver Code Ends
class Solution
{
 public:
   vector<int> meo(vector<int> left, vector<int> right) {
      int l=0, r=0;
      vector<int> ans;
      while(l<left.size() && r<right.size()) {
         if(left[l]%2==0 && right[r]%2!=0)
            ans.push_back(right[r++]);
         else if(left[l]%2!=0 && right[r]%2==0)
            ans.push_back(left[l++]);
         else if(left[l]%2!=0) {
            if(left[l] > right[r])
               ans.push_back(left[l++]);
            else
               ans.push_back(right[r++]);
         }
         else {
            if(left[l] < right[r])
               ans.push_back(left[l++]);
            else
               ans.push_back(right[r++]);
         }
      }
      while(l<left.size()) ans.push_back(left[l++]);
      while(r<right.size()) ans.push_back(right[r++]);
      return ans;
   }
```

$$\left[\begin{array}{l} T = O(n\log n) \\ S = \underline{\underline{O(n)}} \end{array}\right]$$

```cpp
    vector<int> mseo(vector<int> &nums, int l, int r) {
       if(l==r) return vector<int> {nums[l]};
       int m = (l+r)/2;
       vector<int> left = mseo(nums, l, m);
       vector<int> right = mseo(nums, m+1, r);
       return meo(left, right);
    }
    void sortIt(long long arr[], long long n) {
       vector<int> nums(arr, arr+n);
       vector<int> ans = mseo(nums, 0, nums.size()-1);
       int c=0;
       for(auto n: ans) arr[c++] = n;
    }
};

//{ Driver Code Starts.
int main() {
   long long t;
   cin >> t;
   while (t--) {
      long long n;
      cin >> n;
      long long arr[n];

      for (int i = 0; i < n; i++)
         cin >> arr[i];

      Solution ob;
      ob.sortIt(arr, n);

      for (int i = 0; i < n; i++)
         cout << arr[i] << " ";
      cout << endl;
   }
   return 0;
}
// } Driver Code Ends
```