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Divide and Conquer

4.a. Number of Zeros in a Given Array

Aim: Given an array of 1s and 0s this has all 1s first followed by all 0s. Aim is to find the number of 0s. Write a program using Divide and Conquer to Count the number of zeroes in the given array.

Input Format

First Line Contains Integer m – Size of array

Next m lines Contains m numbers – Elements of an array

Output Format

First Line Contains Integer – Number of zeroes present in the given array.

Algorithm:

```
function count(a, left, right) {
   // base case: if left index exceeds right index
   if left is greater than right {
      return 0
   }

   initialize mid as (left + right) / 2  // find the middle index

   // check if the middle element is 1
   if a[mid] is equal to 1 {
      // check if the next element is 0
      if a[mid + 1] is equal to 0 {
         // count zeros from mid + 1 to right
```

```
            initialize c as (right - (mid + 1)) + 1
            return c
        } else {
            // search in the right half
            return count(a, mid + 1, right)
        }
    }
    // check if both ends are 0
    else if a[left] is equal to 0 and a[right] is equal to 0 {
        return right + 1  // return total count of elements
    }
    // search in the left half
    else {
        return count(a, left, mid - 1)
    }
}

function main() {
    initialize n  // number of elements
    read n from user

    initialize arr array of size n  // array to hold binary values

    // read values into the arr array
    for i from 0 to n - 1 {
        read arr[i] from user
    }
```

initialize left as 0 // left index

initialize right as n - 1 // ri

Program:

```
#include<stdio.h>

int count=0;

void rec(int arr[],int left,int right){

    if(arr[left]==0){
        count = count + (right - left + 1);
    }
    else{
        if(left < right){
            int mid = (left + right)/2;
            rec(arr, left, mid);
            rec(arr, mid + 1, right);
        }
    }
}

int main(){
    int m;
    scanf("%d",&m);

    int arr[m];
    for(int i=0; i<m ;i++){
```

```
        scanf("%d",&arr[i]);
    }

    rec(arr, 0, m-1);

    printf("%d",count);
}
```

Output:

	Input	Expected	Got	
✔	5 1 1 1 0 0	2	2	✔
✔	10 1 1 1 1 1 1 1 1 1 1	0	0	✔
✔	8 0 0 0 0 0 0 0 0	8	8	✔

4.b. Majority Element

Aim: Given an array `nums` of size `n`, return *the majority element*.

The majority element is the element that appears more than `⌊n / 2⌋` times. You may assume that the majority element always exists in the array.

Example 1:

```
Input: nums = [3,2,3]
Output: 3
```

Example 2:

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

Constraints:

- `n == nums.length`
- `1 <= n <= 5 * 10^4`
- `-2^31 <= nums[i] <= 2^31 - 1`

Algorithm:

int divide(a, l, r, n) {

// base case: if left index equals right index

if l is equal to r {

return a[l] // return the only element

}

initialize mid as (l + r) / 2 // find the middle index

// recursively divide the array

initialize min as divide(a, l, mid, n) // find min in left half

initialize max as divide(a, mid + 1, r, n) // find max in right half

initialize leftc as 0 // counter for min occurrences

initialize rightc as 0 // counter for max occurrences

```
    // count occurrences of min and max in the entire array
    for i from 0 to n - 1 {
        if a[i] is equal to min {
            increment leftc by 1  // count occurrences of min
        } else {
            increment rightc by 1  // count occurrences of max
        }
    }

    // check if min occurs more than n/2 times
    if leftc is greater than (n / 2) {
        return min  // return min if it is the majority element
    } else {
        return max  // return max otherwise
    }
}

int main() {
    initialize n  // number of elements
    read n from user

    initialize a array of size n  // array to hold input values

    // read values into the array
    for j from 0 to n - 1 {
        read a[j] from user
    }
```

```
    initialize l as 0  // left index
    initialize r as n - 1  // right index

    // call the divide function
    initialize result as divide(a, l, r, n)

    print result  // output the final majority element
}
```

Program:

```
#include <stdio.h>

int findMajorityElement(int nums[], int n) {
    int count = 0;
    int candidate = nums[0];

    for (int i = 0; i < n; i++) {
        if (count == 0) {
            candidate = nums[i];
        }
        count += (nums[i] == candidate) ? 1 : -1;
    }

    return candidate;
}

int main() {
```

```
    int num;
    scanf("%d",&num);
    int arr[num];

    for(int i=0; i<num; i++){
        int val;
        scanf("%d",&val);
        arr[i] = val;
    }

    printf("%d",findMajorityElement(arr,num));

    return 0;
}
```

Output:

	Input	Expected	Got	
✔	3 3 2 3	3	3	✔

4.c. Finding Floor Value

Aim: Given a sorted array and a value x, the floor of x is the largest element in array smaller than or equal to x. Write divide and conquer algorithm to find floor of x.

Input Format

First Line Contains Integer n – Size of array

Next n lines Contains n numbers – Elements of an array

Last Line Contains Integer x – Value for x

Output Format

First Line Contains Integer – Floor value for x

Algorithm:

```
int large(arr, l, r, x){
    // Base case: if the range is invalid
    if r < l
        return 0  // return 0 when there is no valid element

    // Calculate the middle index
    mid = (l + r) / 2

    // Check if the middle element is equal to x
    if arr[mid] is equal to x
        return mid  // return the index of x if found

    // If the middle element is less than x
    else if arr[mid] < x
        // Recursively search in the right half
        floorIndex = large(arr, mid + 1, r, x)

        // Check if a valid floor index is found
```

```
        if floorIndex is not equal to 0
            return floorIndex  // return the found index
        else
            return mid  // return mid as the largest element less than x

    // If the middle element is greater than x, search in the left half
    else
        return large(arr, l, mid - 1, x)  // search in the left half
}
Int main()
    initialize n  // number of elements in the array
    read n from user

    initialize arr of size n  // array to hold input values

    // Read values into the array
    for i from 0 to n - 1
        read arr[i] from user

    initialize l as 0  // left index
    initialize r as n - 1  // right index

    initialize x  // the value for which we want to find the largest element less than or equal to
x
    read x from user

    // Call the large function
    result = large(arr, l, r, x)
```

```
    // Check the result
    if result is equal to 0
        print x  // if no valid element, print x
    else
        print arr[result]  // print the largest element less than or equal to x
```

Program:

```
#include <stdio.h>

int find(int arr[], int n, int x) {
    int low = 0;
    int high = n - 1;
    int result = -1;

    while (low <= high) {
        int mid = low + (high - low) / 2;

        if (arr[mid] == x) {
            return arr[mid];
        } else if (arr[mid] < x) {
            result = arr[mid];
            low = mid + 1;
        } else {
            high = mid - 1;
        }
    }
```

```
    return result;
}



int main(){
    int n;
    scanf("%d",&n);
    int arr[n];

    for(int i=0; i<n; i++){
        int val;
        scanf("%d",&val);
        arr[i] = val;
    }

    int x;

    scanf("%d", &x);

    int Value = find(arr, n, x);
    printf("%d\n", Value);
}
```

Output:

	Input	Expected	Got	
✔	6 1 2 8 10 12 19 5	2	2	✔
✔	5 10 22 85 108 129 100	85	85	✔
✔	7 3 5 7 9 11 13 15 10	9	9	✔

4.d. Two Elements Sum to X

Aim: Given a sorted array of integers say arr[] and a number x. Write a recursive program using divide and conquer strategy to check if there exist two elements in the array whose sum = x. If there exist such two elements then return the numbers, otherwise print as "No".
Note: Write a Divide and Conquer Solution
Input Format
First Line Contains Integer n – Size of array
Next n lines Contains n numbers – Elements of an array
Last Line Contains Integer x – Sum Value
Output Format
First Line Contains Integer – Element1
Second Line Contains Integer – Element2 (Element 1 and Elements 2 together sums to value "x")

Algorithm:

```
int findPairWithSum(arr, left, right, x){
    // Base case: if there are no more pairs to check
    if left >= right
        print "No"  // No pair found
        return

    // Calculate the sum of the elements at the left and right indices
    sum = arr[left] + arr[right]

    // Check if the sum is equal to x
    if sum is equal to x
        print arr[left]  // Print the first element of the pair
        print arr[right]  // Print the second element of the pair
        return

    // If the sum is less than x, move the left index up
```

```
    if sum < x
        findPairWithSum(arr, left + 1, right, x)  // Recursive call with increased left index
    else
        findPairWithSum(arr, left, right - 1, x)  // Recursive call with decreased right index
}
function main()
    initialize n  // number of elements in the array
    read n from user

    initialize arr of size n  // array to hold input values

    // Read values into the array
    for i from 0 to n - 1
        read arr[i] from user

    initialize x  // the target sum value
    read x from user

    // Call the findPairWithSum function
    findPairWithSum(arr, 0, n - 1, x)
```

Program:

```
#include <stdio.h>

int find(int arr[], int l, int h, int a) {
    if (l >= h) return 0;

    int count = arr[l] + arr[h];
```

```
    if (count == a) {
        printf("%d\n", arr[l]);
        printf("%d\n", arr[h]);
        return 1;
    }

    if (count < a) {
        return find(arr, l + 1, h, a);
    }

    return find(arr, l, h - 1, a);
}

int main() {
    int n, x;
    scanf("%d", &n);

    int arr[n];
    for (int i = 0; i < n; i++) {
        scanf("%d", &arr[i]);
    }

    scanf("%d", &x);
    if (!find(arr, 0, n - 1, x)) {
        printf("No\n");
    }
```

```
    return 0;
}
```

Output:

	Input	Expected	Got	
✔	4 2 4 8 10 14	4 10	4 10	✔
✔	5 2 4 6 8 10 100	No	No	✔

4.e. Implementation of Quick Sort

Aim: Write a Program to Implement the Quick Sort Algorithm

Input Format:
The first line contains the no of elements in the list-n
The next n lines contain the elements.

Output:
Sorted list of elements

Algorithm:

```
int partition(a, left, right)
{
    pivot = right  // Choose the last element as pivot
    i = left - 1   // Index of smaller element

    for j from left to right - 1
    {
        if a[j] < a[pivot]
        {
            i++
            // Swap a[i] and a[j]
            temp = a[i]
            a[i] = a[j]
            a[j] = temp
        }
    }

    // Swap a[i + 1] and a[right]
    temp = a[i + 1]
    a[i + 1] = a[right]
```

```
    a[right] = temp
    return (i + 1)   // Return the partition index
}

function quick(a, left, right)
{
    if left < right
    {
        p = partition(a, left, right)  // Partition the array
        quick(a, left, p - 1)          // Recursively sort the left sub-array
        quick(a, p + 1, right)         // Recursively sort the right sub-array
    }
}

int main()
{
    initialize n  // number of elements
    read n from user

    initialize a of size n  // array to hold input values
    for i from 0 to n - 1
    {
        read a[i] from user
    }

    quick(a, 0, n - 1)  // Call the quicksort function

    // Print the sorted array
```

```
    for i from 0 to n - 1
    {
        print a[i]
    }
}
```

Program:

```
#include <stdio.h>

int divide(int arr[], int l, int h) {
    int p = arr[l], i = l, j = h;
    int temp;

    while(i < j){
        while(arr[i] <= p && i <= h - 1) i++;
        while(arr[j] >= p && j >= l + 1) j--;
        if(i < j) {
            temp = arr[i];
            arr[i] = arr[j];
            arr[j] = temp;
        }
    }

    temp = arr[l];
    arr[l] = arr[j];
    arr[j] = temp;
    return j;
}
```

```
void quickSort(int arr[], int l, int h) {
    if(l < h) {
        int mid = divide(arr, l, h);
        quickSort(arr, l, mid - 1);
        quickSort(arr, mid + 1, h);
    }
}

int main() {

    int N;
    scanf("%d", &N);

    int arr[N];
    for(int i = 0; i < N; i++) {
        scanf("%d", &arr[i]);
    }

    quickSort(arr, 0, N - 1);

    for(int i = 0; i < N; i++) {
        printf("%d ", arr[i]);
    }

    return 0;
}
```

Output:

	Input	Expected	Got	
✔	5 67 34 12 98 78	12 34 67 78 98	12 34 67 78 98	✔
✔	10 1 56 78 90 32 56 11 10 90 114	1 10 11 32 56 56 78 90 90 114	1 10 11 32 56 56 78 90 90 114	✔
✔	12 9 8 7 6 5 4 3 2 1 10 11 90	1 2 3 4 5 6 7 8 9 10 11 90	1 2 3 4 5 6 7 8 9 10 11 90	✔