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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(int a[],int left,int right)
{
    if(left>right)
    {
        return 0;
    }
    int mid=(left+right)/2;
    if(a[mid]==1)
    {
        if(a[mid+1]==0)
        {
            int c= (right-(mid+1))+1;
            return c;
        }
        else{
            return count(a,mid+1,right);
        }
    }
    else if(a[left]==0 && a[right]==0)
    {
        return right+1;
    }
    else
```

```
    {
        return count(a,left,mid-1);
    }


}
int main()
{
    int n;
    scanf("%d",&n);
    int arr[n];
    for(int i=0;i<n;i++){
        scanf("%d",&arr[i]);
    }
    int left=0;
    int right=n-1;
    int result=count(arr,left,right);
    printf("%d",result);
}
```

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 sizne , return *the majority element*.

The majority element is the element that appears more than $\lfloor n / 2 \rfloor$ 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 * 104 -2 <= nums[i]
<=31231 - 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 divide(int a[],int l,int r,int n){
    if(l==r)
    {
        return a[l];
    }
    int mid=(l+r)/2;
    int min=divide(a,l,mid,n);
    int max=divide(a,mid+1,r,n);
    int leftc=0,rightc=0;
    for(int i=0;i<n;i++)
    {
        if(a[i]==min)
        {
            leftc++;
        }
        else
```

```
        {
            rightc++;
        }
    }
    if(leftc>(n/2))
    {
        return min;

    }
    else
    {
        return max;
    }
}
int main(){
int n;
scanf("%d",&n);
int a[n];
for(int j=0;j<n;j++){
        scanf("%d",&a[j]);
    }
    int l=0,r=n-1;
    int result=divide(a,l,r,n);
    printf("%d",result);
}
```

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 large(int arr[],int l,int r,int x){
    if (r < l) {
        return 0;
    }
    int mid=(l+r)/2;
    if (arr[mid]==x)
    {
        return mid;
    }
    else if (arr[mid]<x)
    {
        int floorIndex=large(arr,mid+1,r,x);
        if(floorIndex!=0)
        {
            return floorIndex;
        }
        else
        {
           return floorIndex=mid;
        }
```

```
    }
    else
    {
        return large(arr,l,mid-1,x);
    }
}

int main(){
int n;
scanf("%d",&n);
int arr[n];
for (int i=0;i<n;i++){
         scanf("%d ",&arr[i]);
    }
    int l=0;
    int r=n-1;
    int x;
    scanf("%d",&x);
    int result=large(arr,l,r,x);
    if (result == 0)
    {
        printf( "%d",x);
    }
    else
    {
        printf( "%d",arr[result]);
    }
```

```
}
```

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>

void findPairWithSum(int arr[], int left, int right, int x) {
    if (left >= right) {
        //No pair found
        printf("No\n");
```

```
        return;
    }

    int sum = arr[left] + arr[right];

    if (sum == x){
        // If the pair is found
        printf("%d\n%d\n", arr[left], arr[right]);
        return;
    }

    if (sum < x){

        findPairWithSum(arr, left + 1, right, x);
    }
    else{

        findPairWithSum(arr, left, right - 1, x);
    }
}
int main() {
    int n;
    scanf("%d", &n);
    int arr[n];
    for (int i = 0; i < n; i++) {
    scanf("%d", &arr[i]);
    }
    int x;
```

```
 scanf("%d", &x);
    findPairWithSum(arr, 0, n - 1, x);
}
```

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 partition(int a[], int left, int right) {
    int pivot = right;
    int i = left-1;

    for (int j = left; j < right; j++) {

        if (a[j] < a[pivot]) {
            i++;
            int temp = a[i];
            a[i] = a[j];
            a[j] = temp;
        }
    }

    int temp = a[i + 1];
    a[i + 1] = a[right];
    a[right] = temp;
    return (i + 1);
```