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Ex. No: 4

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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
```

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```

        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

```

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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);
    }
}
```

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```
}  
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:

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

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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 $\lfloor n / 2 \rfloor$ 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`
- `-231 <= nums[i] <= 231 - 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
```

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```
// 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
```

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```
// 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))
```

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```

    {
        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	3	✓
	3 2 3			

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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
```

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```

        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

```

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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);
```

```
    }
```

```
}
```

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```
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]);
    }
}
```

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Output:

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	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	✓

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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
```

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```

        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];
```

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```
    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	4	4	✓
	2	10	10	
	4			
	8			
	10			
	14			
✓	5	No	No	✓
	2			
	4			
	6			
	8			
	10			
	100			

--	--	--

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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);
```

```
}
```

```
void quick(int a[], int left, int right) {
```

```
    if (left < right) {
```

```
        int p = partition(a, left, right);
```

--	--	--

--	--	--

```

        quick(a, left, p - 1);
        quick(a, p + 1, right);
    }
}

```

```

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

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

    quick(a, 0, n - 1);

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

```

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	✓

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