ASSIGNMENT VII:
Bubble And Merge Sort
U19CS012 [D-12]

1.) Implement the Bubble Sort Algorithm

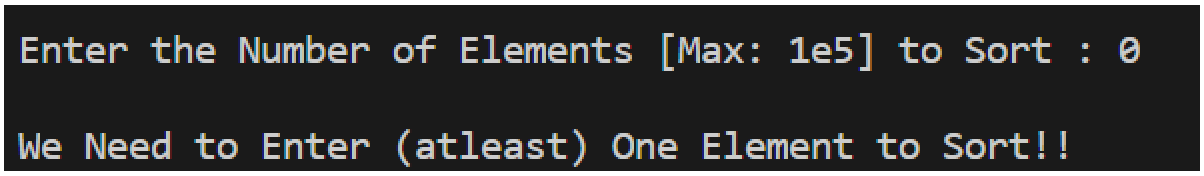
Code:

```c
//Implement Bubble Sort Algorithm

#include <stdio.h>

#define MAX 10001

//Predefined a Static Array of MAX Size
int arr[MAX];

//1 -> Simple Bubble Sort Implementation Always -> O(n^2)
void Bubble_Sort(int arr[], int n);

//2 -> Optimised Bubble Sort Implementation
//Takes Less Iterations if Array is Already Sorted
void Optimized_Bubble_Sort(int arr[], int n);

//Small Helper Function to Print the Array
void print(int arr[], int sz);

int main()
{
    int n;
    printf("\nEnter the Number of Elements [Max: 1e5] to Sort : ");
    scanf("%d", &n);

    // Invalid Input Entered
    if (n < 0)
    {
        printf("\nInvalid Input!\nEnter Positive Number of Elements [>0]!!\n");
        return 0;
    }
    // No Element to Sort
    if (n == 0)
    {
        printf("\nWe Need to Enter (atleast) One Element to Sort!!");
        return 0;
    }

    printf("\nEnter the Values of Array to Sort : \n");
    for (int i = 0; i < n; i++)
    {
        printf("arr[%d] = ", i);
        scanf("%d", &arr[i]);
    }

    int choice;
    printf("Which Bubble Sort to Use \n1 -> Simple \n2 -> Optimized\n");
    printf("Choice : ");
    scanf("%d", &choice);

    switch (choice)
    {
    case 1:
        Bubble_Sort(arr, n);
        break;
    case 2:
        Optimized_Bubble_Sort(arr, n);
        break;
    default:
        printf("Enter a Valid Choice!");
        break;
    }

    return 0;
}

void Bubble_Sort(int arr[], int n)
{
    // Iterators
    int i, j;
    // tmp Variable For Swapping
    int tmp;

    printf("Initial Array : ");
    print(arr, n);
    printf("\n");

    int pass = 1;
    for (i = 0; i < n - 1; i++)
    {
        for (j = 0; j < n - i - 1; j++)
            if (arr[j] > arr[j + 1])
            {
                tmp = arr[j];
                arr[j] = arr[j + 1];
                arr[j + 1] = tmp;
            }
        printf("Array After Pass %d : ", pass);
        print(arr, n);
        printf("\n");
        pass += 1;
    }
    printf("Sorted Array : ");
    print(arr, n);
    printf("\n");
}

void Optimized_Bubble_Sort(int arr[], int n)
{
    // Iterators
    int i, j;
    // tmp Variable For Swapping
    int tmp;

    printf("Initial Array : ");
    print(arr, n);
    printf("\n");

    int pass = 1;
    int flag = 0;
    for (i = 0; i < n - 1; i++)
    {
        flag = 0;
        for (j = 0; j < n - i - 1; j++)
            if (arr[j] > arr[j + 1])
            {
                tmp = arr[j];
                arr[j] = arr[j + 1];
                arr[j + 1] = tmp;
                flag = 1;
            }
        printf("Array After Pass %d : ", pass);
        print(arr, n);
        printf("\n");
        pass += 1;
        // flag -> 0 ; When No Element is Swapped
        if (flag == 0)
        {
            break;
        }
    }
    printf("Sorted Array : ");
    print(arr, n);
    printf("\n");
}

void print(int arr[], int sz)
{
    int i;
    for (i = 0; i < sz; i++)
        printf("%d ", arr[i]);
    printf("\n");
}
```

Test Cases:

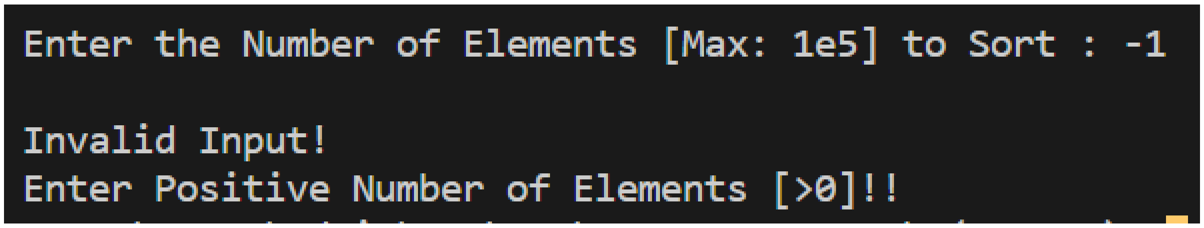
A.) *Check for Invalid inputs*

-> No Element to Sort {0}



```
Enter the Number of Elements [Max: 1e5] to Sort : 0

We Need to Enter (atleast) One Element to Sort!!
```

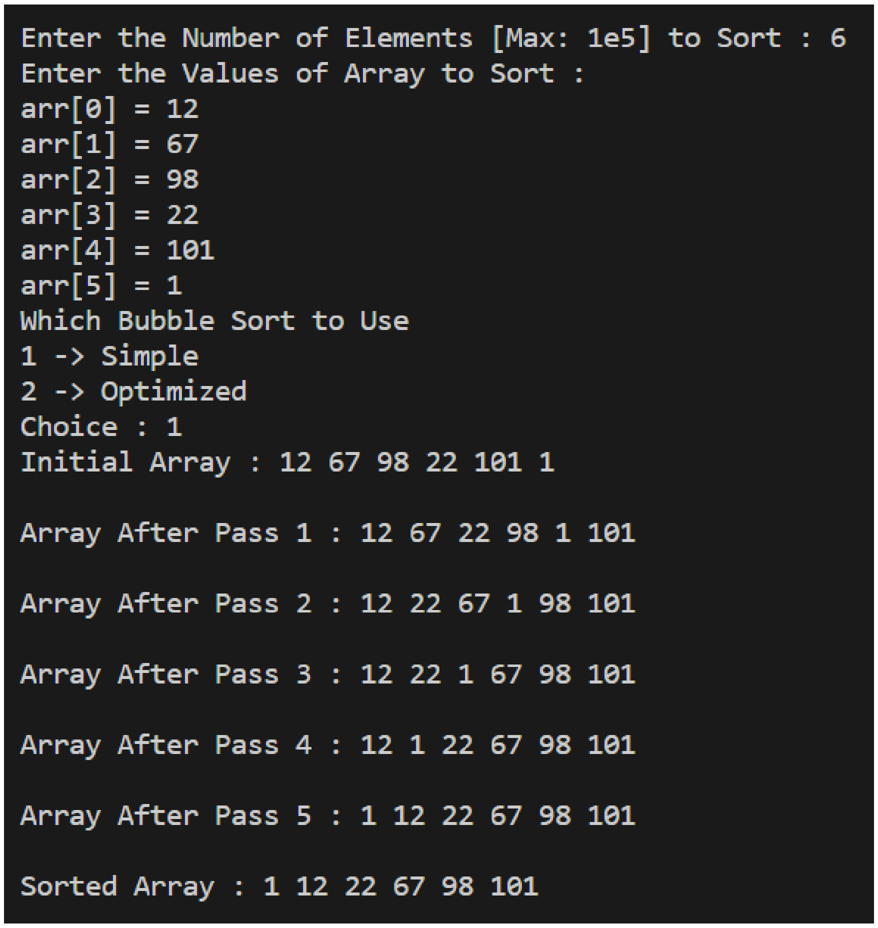
-> Invalid Input {-1}



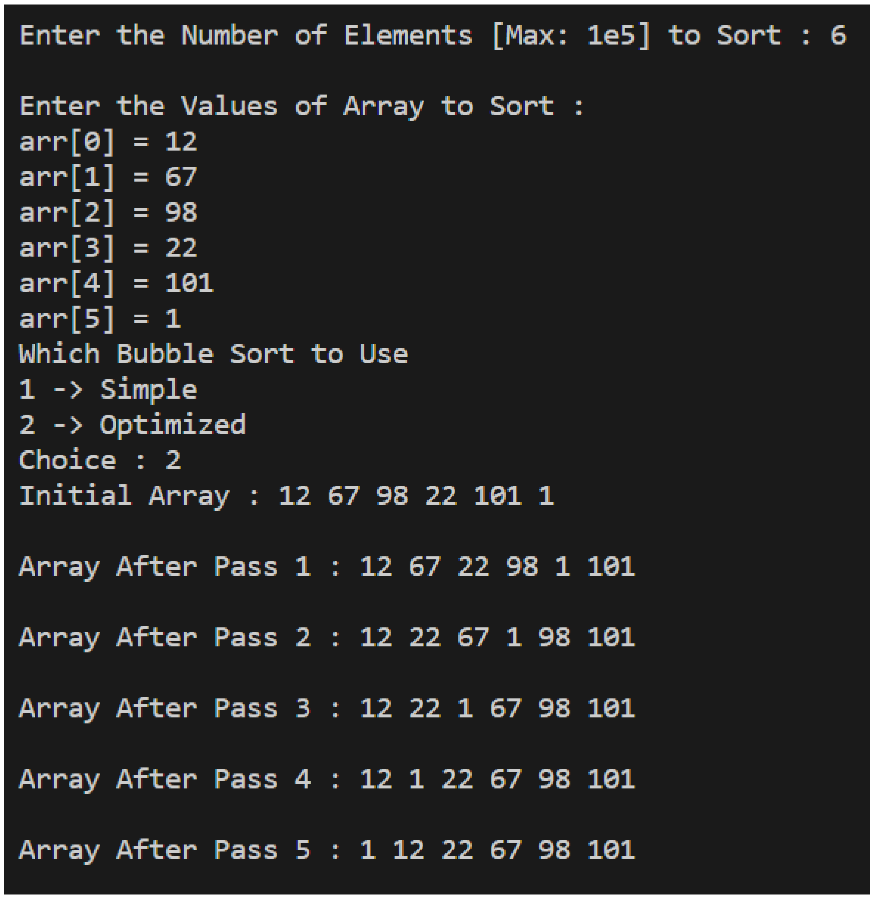
```
Enter the Number of Elements [Max: 1e5] to Sort : -1

Invalid Input!
Enter Positive Number of Elements [>0]!!
```

B.) *Random Unsorted Array*

{12,67,98,22,101,1} -> {1,12,22,67,98,101} [Both Simple & Optimized]



```
Enter the Number of Elements [Max: 1e5] to Sort : 6
Enter the Values of Array to Sort :
arr[0] = 12
arr[1] = 67
arr[2] = 98
arr[3] = 22
arr[4] = 101
arr[5] = 1
Which Bubble Sort to Use
1 -> Simple
2 -> Optimized
Choice : 1
Initial Array : 12 67 98 22 101 1

Array After Pass 1 : 12 67 22 98 1 101

Array After Pass 2 : 12 22 67 1 98 101

Array After Pass 3 : 12 22 1 67 98 101

Array After Pass 4 : 12 1 22 67 98 101

Array After Pass 5 : 1 12 22 67 98 101

Sorted Array : 1 12 22 67 98 101
```



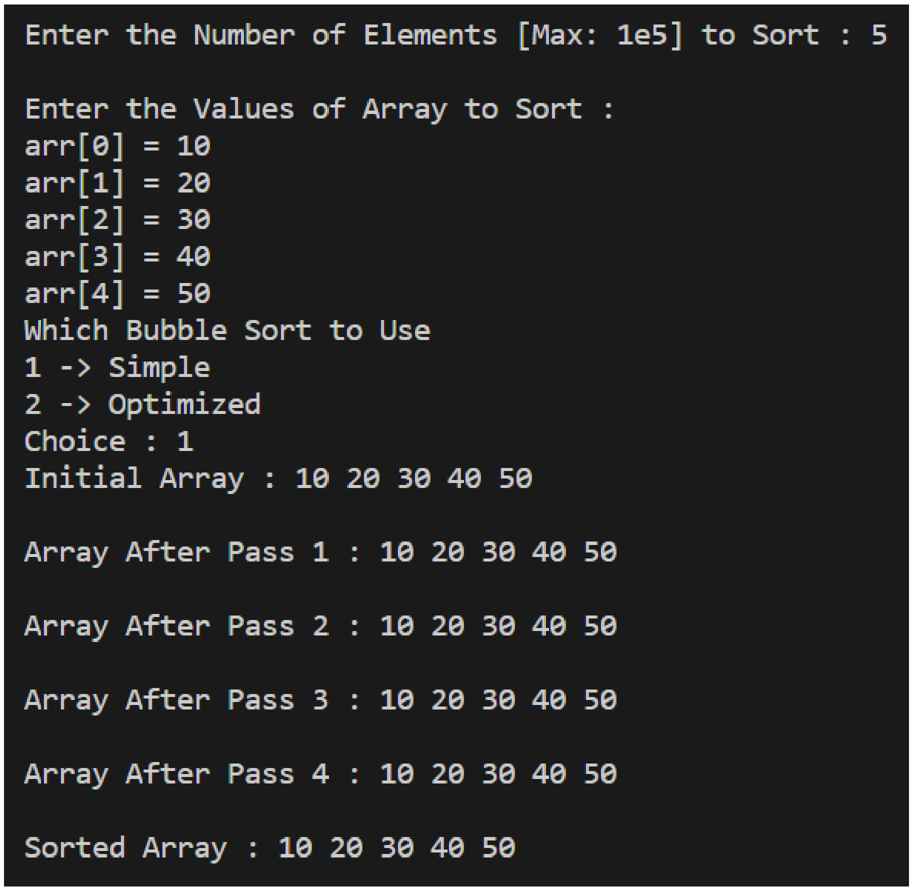
```
Enter the Number of Elements [Max: 1e5] to Sort : 6

Enter the Values of Array to Sort :
arr[0] = 12
arr[1] = 67
arr[2] = 98
arr[3] = 22
arr[4] = 101
arr[5] = 1
Which Bubble Sort to Use
1 -> Simple
2 -> Optimized
Choice : 2
Initial Array : 12 67 98 22 101 1

Array After Pass 1 : 12 67 22 98 1 101

Array After Pass 2 : 12 22 67 1 98 101

Array After Pass 3 : 12 22 1 67 98 101

Array After Pass 4 : 12 1 22 67 98 101

Array After Pass 5 : 1 12 22 67 98 101
```

C.) *Sorted Array*

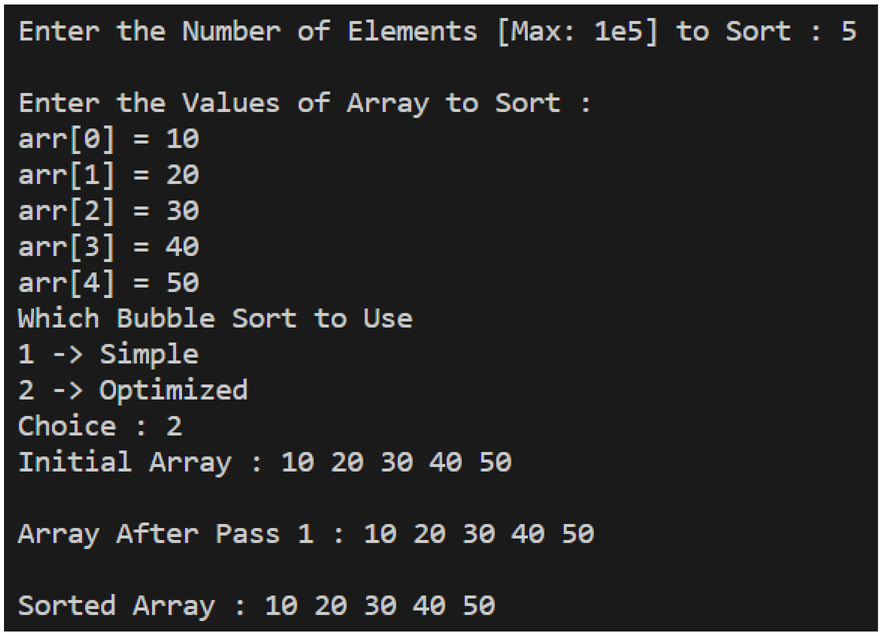
{10, 20, 30, 40, 50} -> {10, 20, 30, 40, 50} [Simple] (n-1 Iterations)

{10, 20, 30, 40, 50} -> {10, 20, 30, 40, 50} [Optimized] (1 Iteration)

[If Array is Sorted, Loop Breaks in Optimized]



```
Enter the Number of Elements [Max: 1e5] to Sort : 5

Enter the Values of Array to Sort :
arr[0] = 10
arr[1] = 20
arr[2] = 30
arr[3] = 40
arr[4] = 50
Which Bubble Sort to Use
1 -> Simple
2 -> Optimized
Choice : 1
Initial Array : 10 20 30 40 50

Array After Pass 1 : 10 20 30 40 50

Array After Pass 2 : 10 20 30 40 50

Array After Pass 3 : 10 20 30 40 50

Array After Pass 4 : 10 20 30 40 50

Sorted Array : 10 20 30 40 50
```



```
Enter the Number of Elements [Max: 1e5] to Sort : 5

Enter the Values of Array to Sort :
arr[0] = 10
arr[1] = 20
arr[2] = 30
arr[3] = 40
arr[4] = 50
Which Bubble Sort to Use
1 -> Simple
2 -> Optimized
Choice : 2
Initial Array : 10 20 30 40 50

Array After Pass 1 : 10 20 30 40 50

Sorted Array : 10 20 30 40 50
```

2) Implement the Merge Sort Algorithm

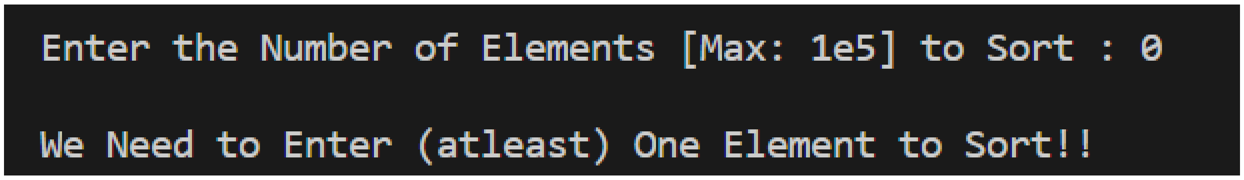
Code:

```c
//Implement Bubble Sort Algorithm

#include <stdio.h>

#define MAX 10001

//Predefined a Static Array of MAX Size
int arr[MAX];

//Recursive Function To Keep on Dividing the Array
void MergeSort(int arr[], int l, int r);

//Function to Merge the Divided Sub-Arrays
void merge(int arr[], int start, int mid, int end);

//Small Helper Function to Print the Array
void print(int arr[], int sz);

int main()
{
    int n;
    printf("\nEnter the Number of Elements [Max: 1e5] to Sort : ");
    scanf("%d", &n);

    // Invalid Input Entered
    if (n < 0)
    {
        printf("\nInvalid Input!\nEnter Positive Number of Elements [>0]!!\n");
        return 0;
    }
    // No Element to Sort
    if (n == 0)
    {
        printf("\nWe Need to Enter (atleast) One Element to Sort!!");
        return 0;
    }

    printf("\nEnter the Values of Array to Sort : \n");

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

    printf("Initial Array : ");
    print(arr, n);
    printf("\n");

    MergeSort(arr, 0, n - 1);

    printf("Sorted Array : ");
    print(arr, n);
    printf("\n");

    return 0;
}

void merge(int arr[], int start, int mid, int end)
{
    // create a temp array
    int temp[end - start + 1];

    // Iterators for both intervals
    int i = start, j = mid + 1;

    // Iterators for temp
    int k = 0;

    // traverse both arrays and in each iteration add smaller of both elements in temp
    while (i <= mid && j <= end)
    {
        if (arr[i] <= arr[j])
        {
            temp[k] = arr[i];
            k += 1;
            i += 1;
        }
        else
        {
            temp[k] = arr[j];
            k += 1;
            j += 1;
        }
    }

    // add elements left in the first interval
    while (i <= mid)
    {
        temp[k] = arr[i];
        k += 1;
        i += 1;
    }

    // add elements left in the second interval
    while (j <= end)
    {
        temp[k] = arr[j];
        k += 1;
        j += 1;
    }

    // Copy Elements Back to Original Array
    for (i = start; i <= end; i += 1)
    {
        arr[i] = temp[i - start];
    }
}

//Recursive Function To Keep on Dividing the Array
void MergeSort(int arr[], int start, int end)
{
    int n = start + end + 1;
    int mid;

    if (start < end)
    {
        // To Avoid Overflow
        mid = start + (end - start) / 2;

        // Divide and Sort First Half
        MergeSort(arr, start, mid);

        // Divide and Sort Second Half
        MergeSort(arr, mid + 1, end);

        //Now Merge the Two Halfs
        merge(arr, start, mid, end);
    }
}

void print(int arr[], int sz)
{
    int i;
    for (i = 0; i < sz; i++)
        printf("%d ", arr[i]);
    printf("\n");
}
```

Test Cases:

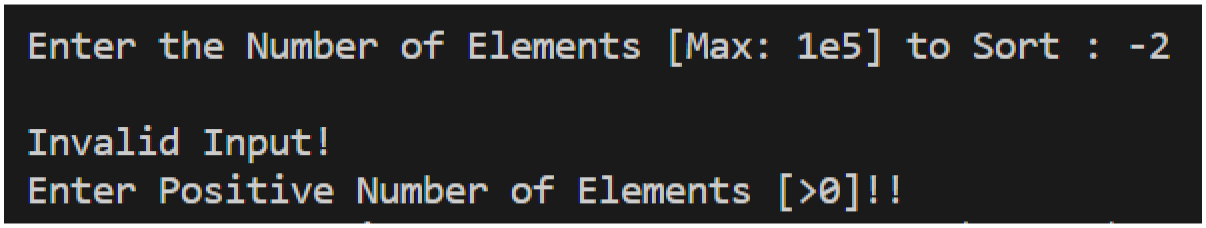
A.) *Check for Invalid inputs*

-> No Element to Sort {0}



```
Enter the Number of Elements [Max: 1e5] to Sort : 0

We Need to Enter (atleast) One Element to Sort!!
```

-> Invalid Input {-2}

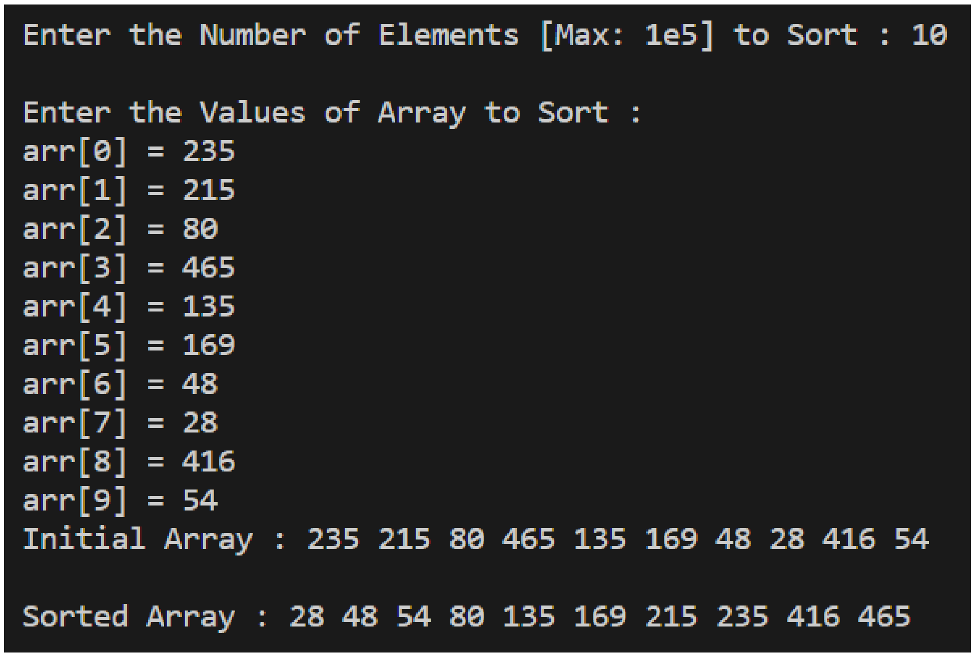


```
Enter the Number of Elements [Max: 1e5] to Sort : -2

Invalid Input!
Enter Positive Number of Elements [>0]!!
```

B.)

{235, 215, 80, 465, 135, 169, 48, 28, 416, 54}

{28, 48, 54, 80, 135, 169, 215, 235, 416, 465}



```
Enter the Number of Elements [Max: 1e5] to Sort : 10

Enter the Values of Array to Sort :
arr[0] = 235
arr[1] = 215
arr[2] = 80
arr[3] = 465
arr[4] = 135
arr[5] = 169
arr[6] = 48
arr[7] = 28
arr[8] = 416
arr[9] = 54
Initial Array : 235 215 80 465 135 169 48 28 416 54

Sorted Array : 28 48 54 80 135 169 215 235 416 465
```

Conclusion:

1.) It Doesn't Matter the Array is *Sorted or Not*, Merge Sort Always takes O(n*log(n)) Complexity .i.e. It will Always Divide & Merge the Array No Matter What the Array is! [Non-Adaptive Algorithm]

2.) Similar thing can be said for Bubble Sort [Simple One], it will always takes O (n*n) Complexity .i.e. will Check *n*(n-1)/2 Pairs* for Sorting. This can be taken care using *Flag* in Optimized Bubble Sort!