Batch: A3	**Roll No.: 16010121045**
Experiment No. 3	
Grade: AA / AB / BB / BC / CC / CD /DD	
Signature of the Staff In-charge with date	

Title: Implementation of Quick sort/Merge sort algorithm

Objective: To learn the divide and conquer strategy of solving the problems of different types

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CO to be achieved:

CO 2 Describe various algorithm design strategies to solve different problems and analyze Complexity.

Books/ Journals/ Websites referred:

1. **Ellis horowitz, Sarataj Sahni, S.Rajsekaran," Fundamentals of computer algorithm", University Press**
2. **T.H.Cormen ,C.E.Leiserson,R.L.Rivest and C.Stein," Introduction to algortihtms",2nd Edition ,MIT press/McGraw Hill,2001**
3. **http://en.wikipedia.org/wiki/Quicksort**
4. **https://www.cs.auckland.ac.nz/~jmor159/PLDS210/qsort.html**
5. **http://www.cs.rochester.edu/~gildea/csc282/slides/C07-quicksort.pdf**
6. **http://www.sorting-algorithms.com/quick-sort**
7. **http://www.cse.ust.hk/~dekai/271/notes/L01a/quickSort.pdf**
8. **http://en.wikipedia.org/wiki/Merge_sort**
9. **http://www.personal.kent.edu/~rmuhamma/Algorithms/MyAlgorithms/Sorting/mergeSort.htm**
10. **http://www.sorting-algorithms.com/merge-sort**
11. **http://www.princeton.edu/~achaney/tmve/wiki100k/docs/Merge_sort.html**

Pre Lab/ Prior Concepts:

Data structures, various sorting techniques

Historical Profile:

Quicksort and merge sort are divide-and-conquer sorting algorithm in which division is dynamically carried out. They are one the most efficient sorting algorithms.

New Concepts to be learned:
Number of comparisons, Application of algorithmic design strategy to any problem, Classical problem solving vs Divide-and-Conquer problem solving.

Algorithm Recursive Quick Sort:

```
void quicksort( Integer A[ ], Integer left, Integer right)
//sorts A[left.. right] by using partition() to partition A[left.. right], and then //calling itself //
twice to sort the two subarrays.
{ IF ( left < right ) then
        {       q = partition( A, left, right);
                quicksort( A, left, q–1);
                quicksort( A, q+1, right);
        }
}
```

Integer *partition(integer A*T[], Integer *left*, Integer *right*)
//This function rarranges *A*[*left*..*right*] and finds and returns an integer *q*, such that *A*[*left*], ..., //*A*[*q*–1] <~□*pivot*, *A*[*q*] = *pivot*, *A*[*q*+1], ..., *A*[*right*] > *pivot*, where *pivot* is the first element of //a[left…right], before partitioning.

```
{
pivot = A[left]; lo = left+1; hi = right;
WHILE ( lo ≤ hi)
{       WHILE (A[hi] > pivot)                   hi = hi – 1;
        WHILE ( lo ≤ hi and A[lo] <~pivot)      lo = lo + 1;
        IF ( lo ≤ hi) then                      swap( A[lo], A[hi]);
}
swap(pivot, A[hi]);
 RETURN hi;
}
```

The space complexity of Quick Sort: O(1)

Derivation of best case and worst-case time complexity (Quick Sort)

Best case: pivot element is middle element or near to middle element

= O(nlogn)

Worst case: pivot element is either greatest element or smallest element

= O(n^2)

Algorithm Merge Sort

MERGE-SORT (A, p, r)

// To sort the entire sequence A[1 .. n], make the initial call to the procedure MERGE-SORT (A, //1, n). Array A and indices p, q, r such that $p \le q \le r$ and sub array $A[p .. q]$ is sorted and sub array //$A[q + 1 .. r]$ is sorted. By restrictions on p, q, r, neither sub array is empty.
//OUTPUT: The two sub arrays are merged into a single sorted sub array in $A[p .. r]$.

```
IF p < r                                // Check for base case
  THEN q = FLOOR [(p + r)/2]              // Divide step
       MERGE (A, p, q)                   // Conquer step.
       MERGE (A, q + 1, r)               // Conquer step.
       MERGE (A, p, q, r)                // Conquer step.
```

```
MERGE (A, p, q, r)
{
   n1 ← q − p + 1
   n2 ← r − q
   Create arrays L[1 . . n1 + 1] and R[1 . . n2 + 1]
   FOR i ← 1 TO n1
       DO L[i] ← A[p + i − 1]
    FOR j ← 1 TO n2
       DO R[j] ← A[q + j ]
   L[n1 + 1] ← ∞
   R[n2 + 1] ← ∞
  i ← 1
  j ← 1
  FOR k ← p TO r
     DO IF L[i ] ≤ R[ j]
          THEN A[k] ← L[i]
               i ← i + 1
          ELSE A[k] ← R[j]
               j ← j + 1

}
```

The space complexity of Merge sort: O(n)

Derivation of best case and worst-case time complexity (Merge Sort)

$T(n) = 2T(n/2) + n$

$a = b = 2$

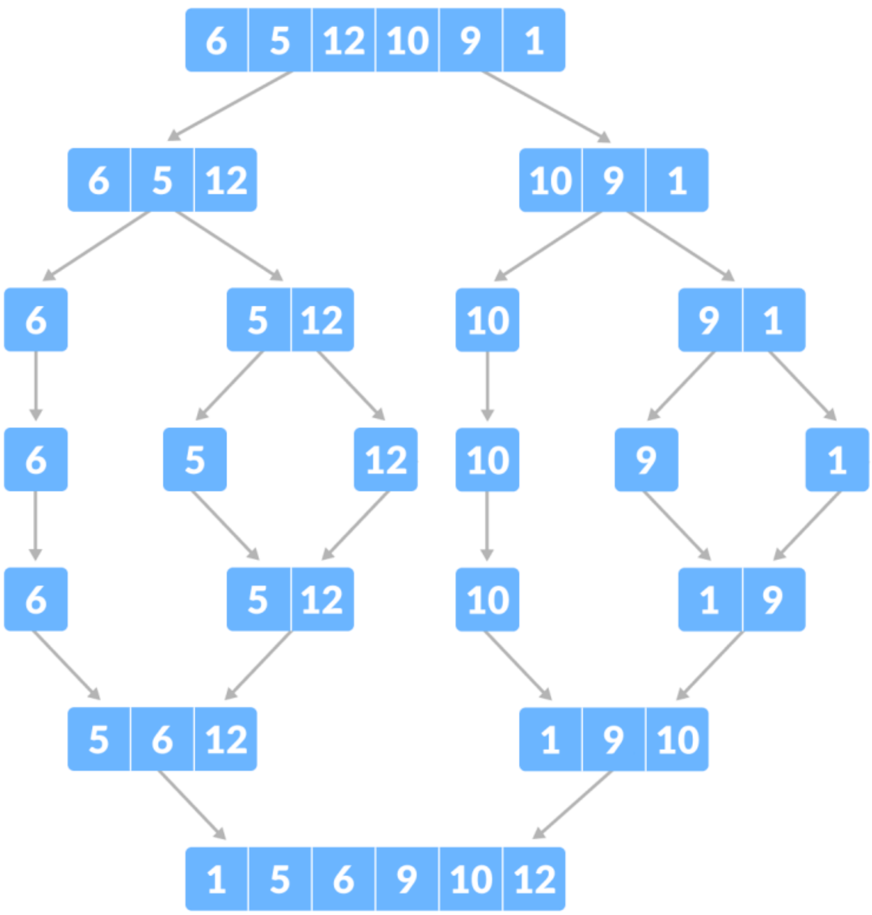
$\log_b a = 1$, $c=1$

Hence, $\theta(n^c \log n) = \theta(n \log n)$

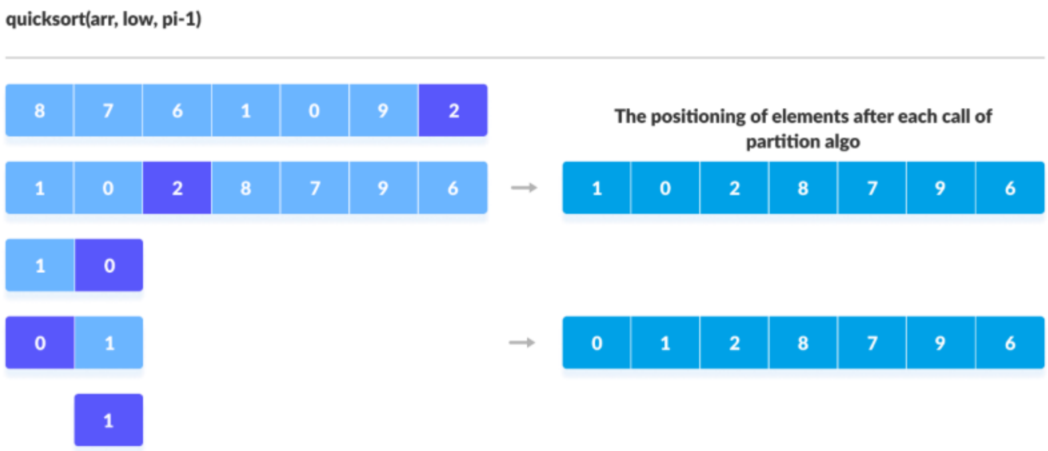
Best Case = Worst Case = $\theta(n \log n)$

Example for quicksort/Merge tree for merge sort:

Merge Sort



Quick Sort:


quicksort(arr, low, pi-1)
The positioning of elements after each call of partition algo


quicksort(arr, pi+1, high)
The positioning of elements after each call of partition algo

Code:

```
#include <bits/stdc++.h>
using namespace std;
void merge(int *arr, int l, int mid, int r)
{
    int arr1[r + 1];
    int i = l, j = mid + 1, k = l;
    while (i <= mid && j <= r)
    {
        if (arr[i] < arr[j])
        {
            arr[j] = arr[i];
            i++;
        }
        else
        {
            arr1[k] = arr[j];
            j++;
        }
        k++;
    }
    if (i > mid)
        while (j <= r)
        {
            arr1[k] = arr[j];
            k++;
            j++;
        }
    else if (j > r)
        while (i <= mid)
        {
            arr1[k] = arr[i];
            k++;
            i++;
        }
    for (k = l; k <= r; k++)
        arr[k] = arr1[k];
}
```

```
void sort(int *arr, int l, int r)
{
    if (l < r)
    {
        int mid = (l + r) / 2;
        sort(arr, l, mid);
        sort(arr, mid + 1, r);
        merge(arr, l, mid, r);
    }
}
int main()
{
    int n;
    cin >> n;
    int arr[n];
    for (int i = 0; i < n; i++)
        cin >> arr[i];
    sort(arr, 0, n - 1);
    for (int i = 0; i < n; i++)
        cout << arr[i] << " ";
    cout << endl;
    return 0;
}
```

CONCLUSION:

Understood and implemented Merge sort and quick sort their time and space complexities