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Subject	Design and Analysis of Algorithms (DAA)
Experiment No.	2
Aim	Experiment based on divide and conquer approach.
Code	

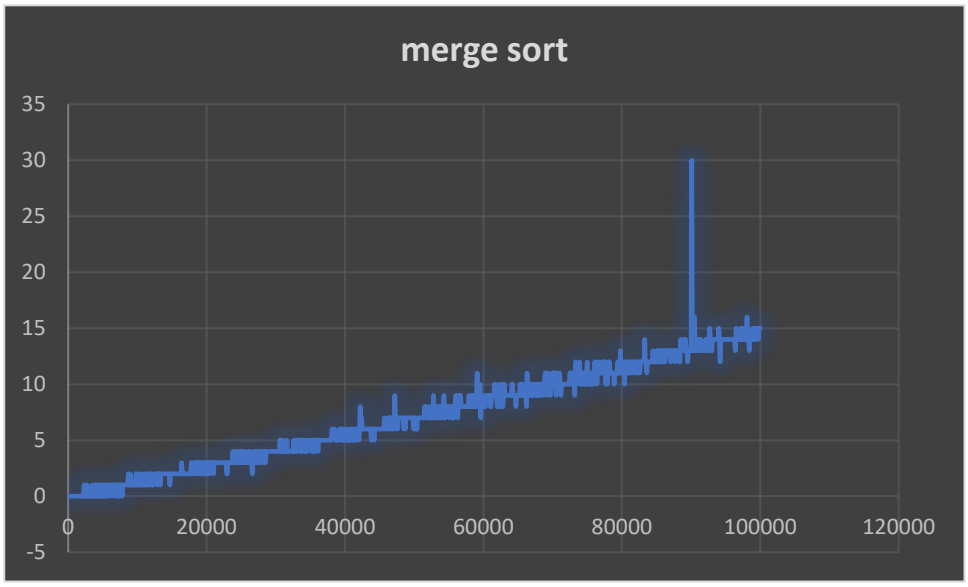
```c
#include <stdio.h>
#include <stdlib.h>
#include <time.h>

void merge(int arr[], int l, int m, int r)
{
    int i, j, k;
    int n1 = m - l + 1;
    int n2 = r - m;

    int L[n1], R[n2];

    for (i = 0; i < n1; i++)
        L[i] = arr[l + i];
    for (j = 0; j < n2; j++)
        R[j] = arr[m + 1 + j];

    i = 0;
    j = 0;
    k = l;
    while (i < n1 && j < n2)
    {
        if (L[i] <= R[j])
        {
            arr[k] = L[i];
            i++;
        }
        else
```

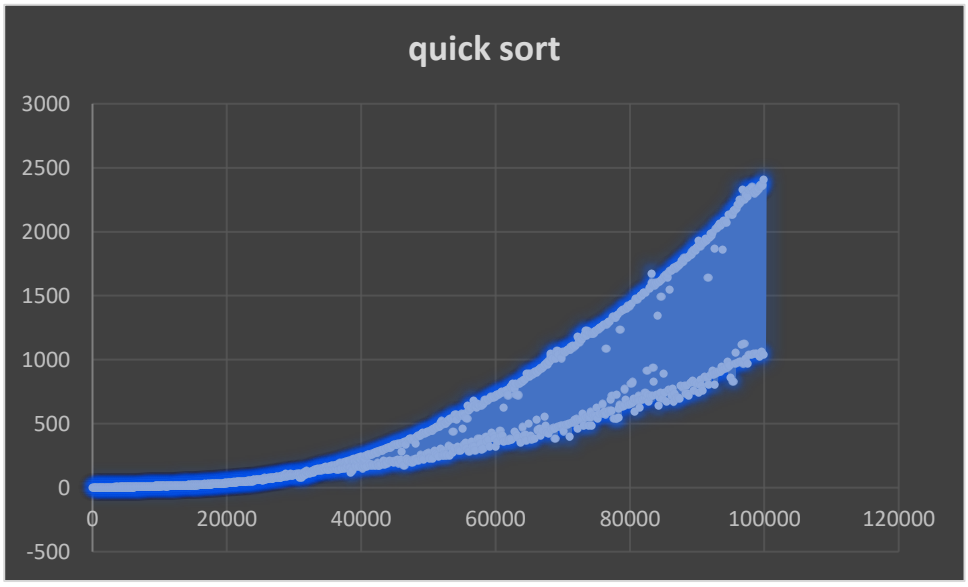
```
        {
            arr[k] = R[j];
            j++;
        }
        k++;
    }

    while (i < n1)
    {
        arr[k] = L[i];
        i++;
        k++;
    }

    while (j < n2)
    {
        arr[k] = R[j];
        j++;
        k++;
    }
}

void mergeSort(int arr[], int l, int r)
{
    if (l < r)
    {
        int m = l + (r - l) / 2;

        mergeSort(arr, l, m);
        mergeSort(arr, m + 1, r);

        merge(arr, l, m, r);
    }
}

void quickSort(int arr[], int low, int high)
{
```

```
    if (low < high)
    {
        int pi = partition(arr, low, high);

        quickSort(arr, low, pi - 1);
        quickSort(arr, pi + 1, high);
    }
}

int partition(int arr[], int low, int high)
{
    int pivot = arr[high];
    int i = (low - 1);

    for (int j = low; j <= high - 1; j++)
    {
        if (arr[j] < pivot)
        {
            i++;
            swap(&arr[i], &arr[j]);
        }
    }

    swap(&arr[i + 1], &arr[high]);
    return (i + 1);
}

void swap(int *a, int *b)
{
    int temp = *a;
    *a = *b;
    *b = temp;
}

void main()
{
    srand(time(NULL));
```

```
    FILE *fileptr;
    FILE *fileptr1;
    int n = 100000;
    fileptr = fopen("inp.txt", "w");
    int arr[n];
    for (int j = 0; j < n; j++)
    {
        arr[j] = rand() % 100000 + 1;
        fprintf(fileptr, "%d\n", arr[j]);
    }
    fclose(fileptr);
    fileptr1 = fopen("time.csv", "w");
    printf("Block Size\tMerge Sort\tQuick Sort\n");
    fileptr = fopen("inp.txt", "r");
    for (int p = 99; p < n; p = p + 100)
    {
        int array[p + 1];
        int array1[p + 1];
        for (int j = 0; j < p; j++)
        {
            array[j] = arr[j];
            fscanf(fileptr, "%1d", &array1[j]);
        }
        clock_t begin = clock();
        mergeSort(array, 0, p);
        clock_t mid = clock();
        quickSort(array1, 0, p);
        clock_t end = clock();
        double time_spent = (double)(mid - begin);
        double time_spent1 = (double)(end - mid);
        printf("%d\t%lf\t%lf\n", p + 1, time_spent, time_spent1);
        fprintf(fileptr1, "%d,%lf,%lf\n", p + 1, time_spent,
time_spent1);
    }
    printf("\n");
}
```

Graphs


merge sort
35
30
25
20
15
10
5
0
-5
0
20000
40000
60000
80000
100000
120000


quick sort
3000
2500
2000
1500
1000
500
0
-500
0
20000
40000
60000
80000
100000
120000

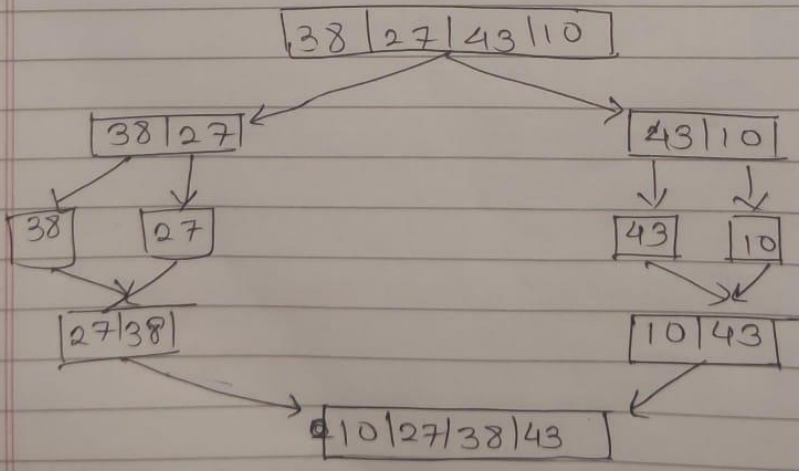
Pseudo Code & Example

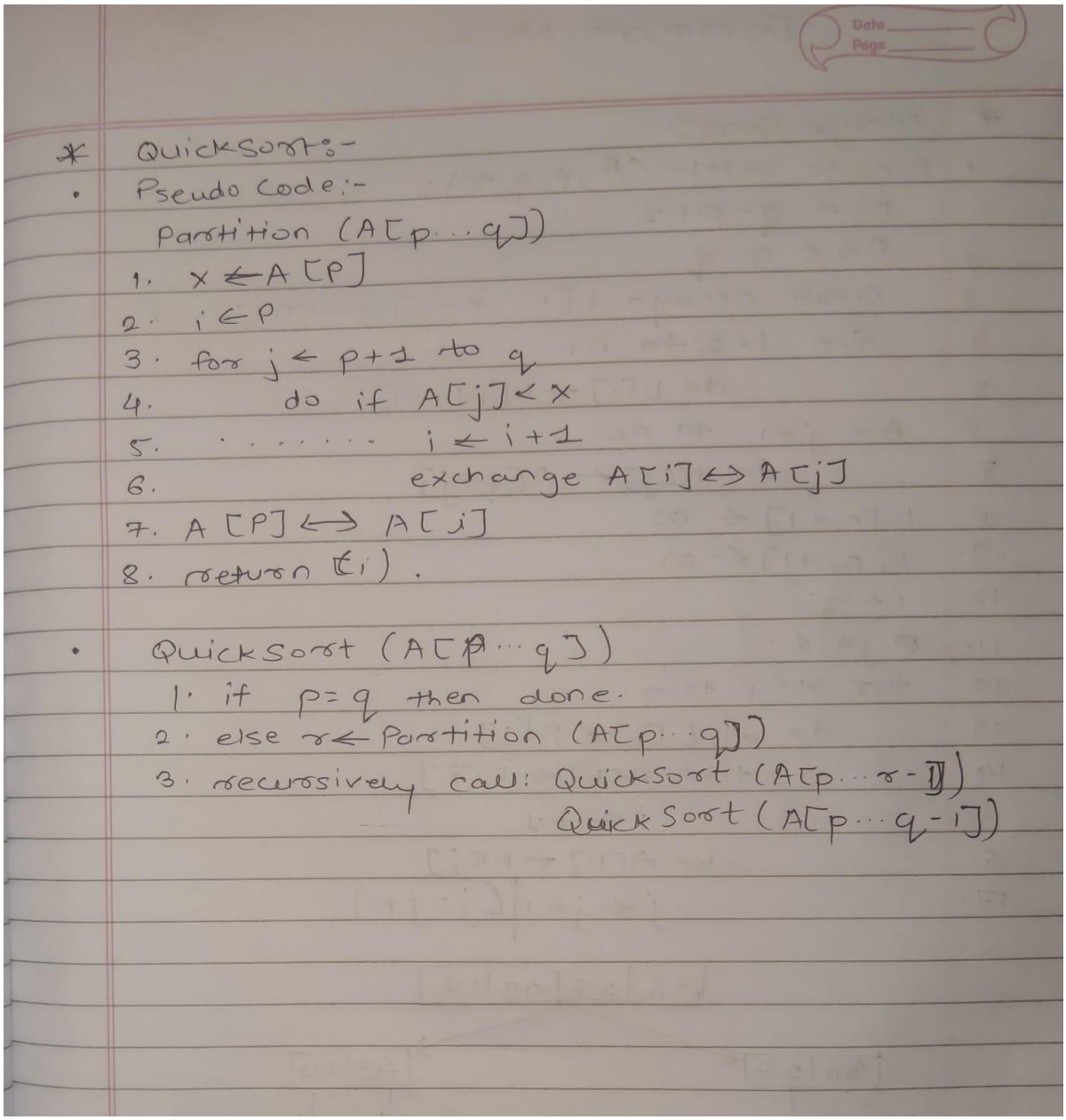
Experiment No. 2

* Merge Sort:-

. Pseudo code:- (A, p, q, r):

1. $n_1 \leftarrow q - p + 1$
2. $n_2 \leftarrow r - q$
3. create arrays $L[1 \cdots n+1]$ and $R[1 \cdots n_2 + 1]$
4. for $i+1$ to n_1
5. do $L[i] \leftarrow A[p+i-1]$
6. for $j+1$ to n_2
7. do $R[j] \leftarrow A[q+j]$
8. $L[n_1+1] \leftarrow \infty$
9. $R[n_2+1] \leftarrow \infty$
10. $i \leftarrow 1$
11. $j \leftarrow 1$.
12. for $k \leftarrow p$ to r
13. do if $L[i] \leq R[j]$
14. then $A[K] \leftarrow L[i]$
15. $i \leftarrow i+1$
16. else $A[K] \leftarrow R[j]$
17. $j \leftarrow j+1$ $(j = j+1)$

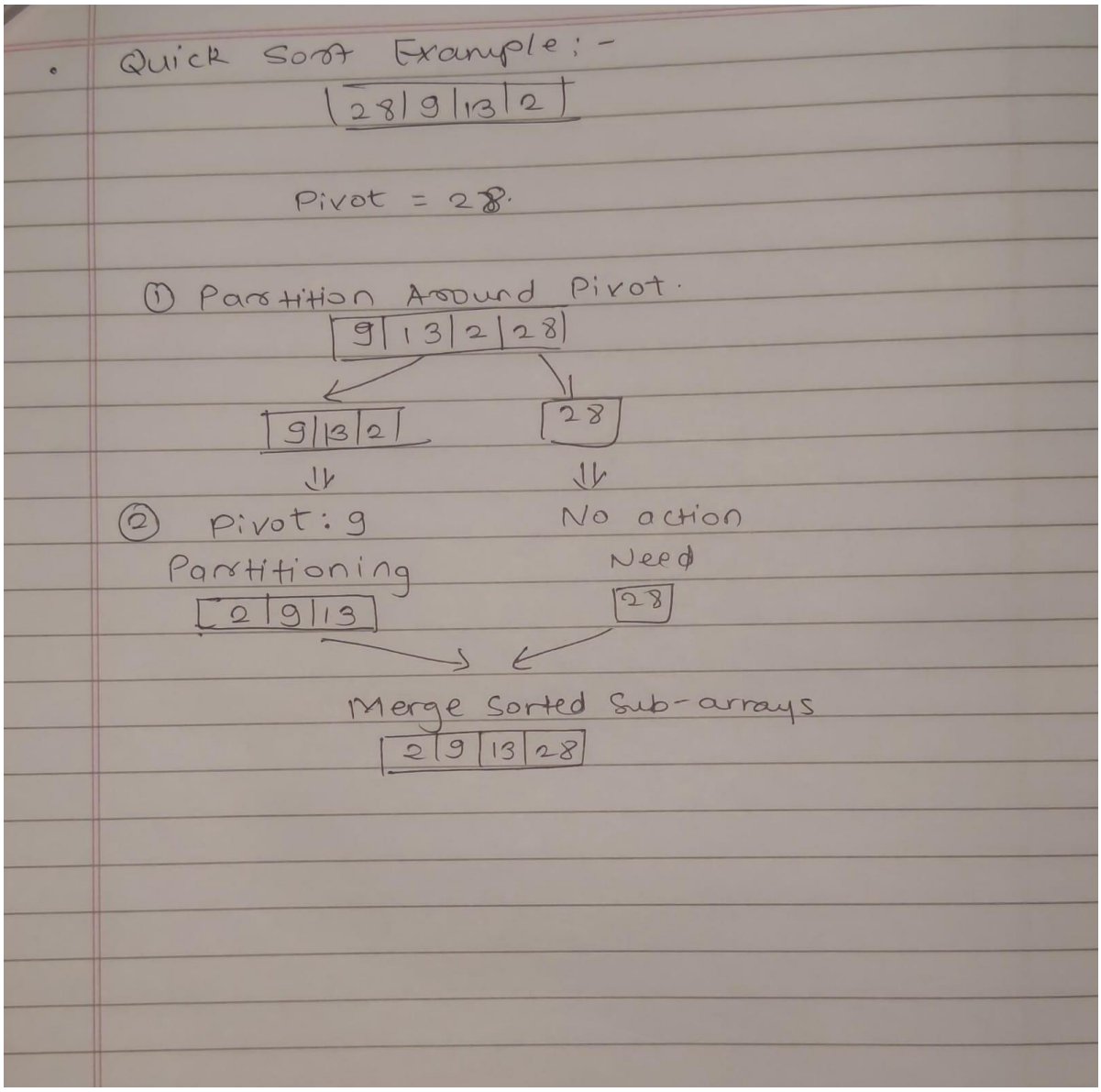




* Quicksort:-
- Pseudo Code:-

Partition (A[p..q])
1. x ← A[p]
2. i ← p
3. for j ← p+1 to q
4. do if A[j] ≤ x
5. ..... i ← i+1
6. exchange A[i] ↔ A[j]
7. A[p] ↔ A[i]
8. return (i).

- Quicksort (A[p..q])
1. if p=q then done.
2. else r ← Partition (A[p..q])
3. recursively call: Quicksort (A[p..r-1])
Quicksort (A[p..q-1])

<table>
<tr><td></td><td> 
</td></tr>
<tr><td>Time Complexity</td><td>Merge Sort:
Merge Sort has a time complexity of O(n log n) in all cases, where n is the number of elements to be sorted. This is because Merge Sort divides the array into halves recursively until each sub-array has only one element, and then it merges these sorted sub-arrays.

Quick Sort:
Quick Sort has an average-case time complexity of O(n log n). However, in the worst-case scenario, where the pivot selection consistently results in unbalanced partitions, Quick Sort can degrade to O(n^2). Despite this worst-case scenario, Quick Sort is often preferred for its average-case performance and is commonly used in practice.</td></tr>
</table>

Space Complexity	**Merge Sort:** Merge Sort has a space complexity of O(n) since it requires additional space to store the merged sub-arrays during the merging phase. However, this additional space is proportional to the size of the input array and is not dependent on the input distribution. **Quick Sort:** Quick Sort has an average-case space complexity of O(log n) due to its recursive nature, as the space required for each recursive call is proportional to the logarithm of the input size. However, in the worst-case scenario, Quick Sort can have a space complexity of O(n) due to the recursion stack reaching its maximum depth if the partitions are highly unbalanced.
Conclusion	Hence, by completing this experiment I came to know about divide and conquer approach.