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SUBJECT	Design and Analysis of Algorithms
EXPERIMENT NO:	2(B)
AIM:	Understanding more concepts regarding quick sort algorithm
Algorithm:	**Quick Sort Algorithm** partition (arr[], low, high) { // pivot (Element to be placed at right position) pivot = arr[high]; i = (low – 1) // Index of smaller element and indicates the // right position of pivot found so far for (j = low; j <= high- 1; j++){ // If current element is smaller than the pivot if (arr[j] < pivot){ i++; // increment index of smaller element swap arr[i] and arr[j] } } swap arr[i + 1] and arr[high])

	return (i + 1) } quickSort(arr[], low, high) { if (low < high) { /* pi is partitioning index, arr[pi] is now at right place */ pi = partition(arr, low, high); quickSort(arr, low, pi – 1); // Before pi quickSort(arr, pi + 1, high); // After pi }
Code:	see code below

```
#include <stdio.h>

#include <stdlib.h>

#include <time.h>

long SWAP = 0;
void merge(int arr[], int p, int q, int r) {
  int i, j, k;
  int n1 = q - p + 1;
  int n2 = r - q;
  int L[n1], R[n2];
  for (i = 0; i < n1; i++)
    L[i] = arr[p + i];
  for (j = 0; j < n2; j++)
    R[j] = arr[q + 1 + j];
  i = 0;
  j = 0;
  k = p;
  while (i < n1 && j < n2) {
```

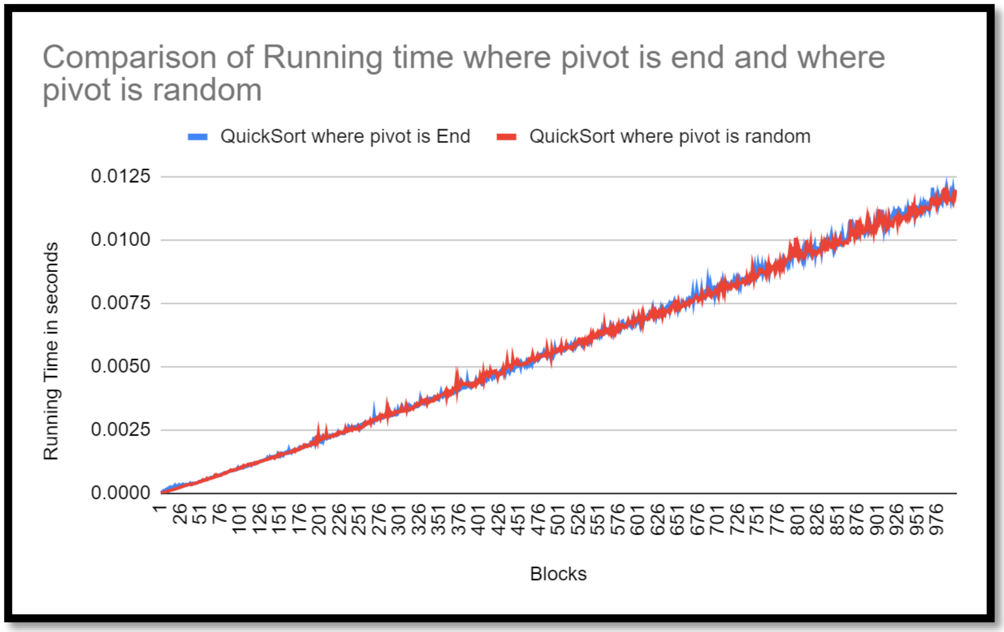
	`` if (L[i] <= R[j]) { arr[k] = L[i]; i++; } else { arr[k] = R[j]; j++; } k++; } while (i < n1) { arr[k] = L[i]; i++; k++; } while (j < n2) { arr[k] = R[j]; j++; k++; } } void mergeSort(int arr[], int l, int r) { if (l < r) { int m = l + (r - l) / 2; mergeSort(arr, l, m); mergeSort(arr, m + 1, r); merge(arr, l, m, r); } } int quicksort(int a[], int start, int end) { int pivot = a[end]; //int pivot = a[start]; //int random = start + rand() % (end - start); //int pivot = a[random]; ```

	`` //int mid = start + (end - start)/2; //int pivot = a[mid]; int i = (start - 1); for (int j = start; j <= end - 1; j++) { if (a[j] < pivot) { i++; int t = a[i]; a[i] = a[j]; a[j] = t; SWAP++; } } int t = a[i + 1]; a[i + 1] = a[end]; a[end] = t; SWAP++; return (i + 1); } double quick(int a[], int start, int end) { if (start < end) { int p = quicksort(a, start, end); quick(a, start, p - 1); quick(a, p + 1, end); } } int main() { double qust, mest; srand(time(0)); FILE * fp, * file; fp = fopen("random.txt", "w"); for (int i = 0; i < 100000; i++) { fprintf(fp, "%d\n", rand() % 900001 + 100000); } int upper_limit = 100; fclose(fp); ```

```
  file = fopen("outputEnd.txt", "w");
  fprintf(file,
"Block\tMerSort\tQuickSort\tSwaps\n");
  for (int i = 0; i < 1000; i++) {
    fp = fopen("random.txt", "r");
    int arr1[upper_limit], arr2[upper_limit],
temp_num;
    for (int j = 0; j < upper_limit; j++) {
      fscanf(fp, "%d", & temp_num);
      arr1[j] = temp_num;
      arr2[j] = temp_num;
    }
    fclose(fp);
    clock_t t;
    t = clock();
    mergeSort(arr2, 0, upper_limit - 1);
    t = clock() - t;
    mest = ((double) t) / CLOCKS_PER_SEC;
    clock_t t1;
    t1 = clock();
    qust = quick(arr1, 0, upper_limit - 1);
    t1 = clock() - t1;
    qust = ((double) t1) / CLOCKS_PER_SEC;
    fprintf(file, "%d\t%lf\t%lf\t%ld\n", i + 1,
mest, qust, SWAP);
    fflush(stdout);
    upper_limit += 100;
  }
  return 0;
}
```

Graphs and Observation:

Running time comparison for Different Pivot Positions



- Here, we can see that the time complexity of quick sort is nearly the same even when varied pivot points are taken into account.
- We can see that a quick sort when the pivot is at a random position takes longer than when the pivot is in an end position at the conclusion of execution.
- Despite the fact that both executions are finished in 0.1 seconds.

Number of swaps considering different pivot positions

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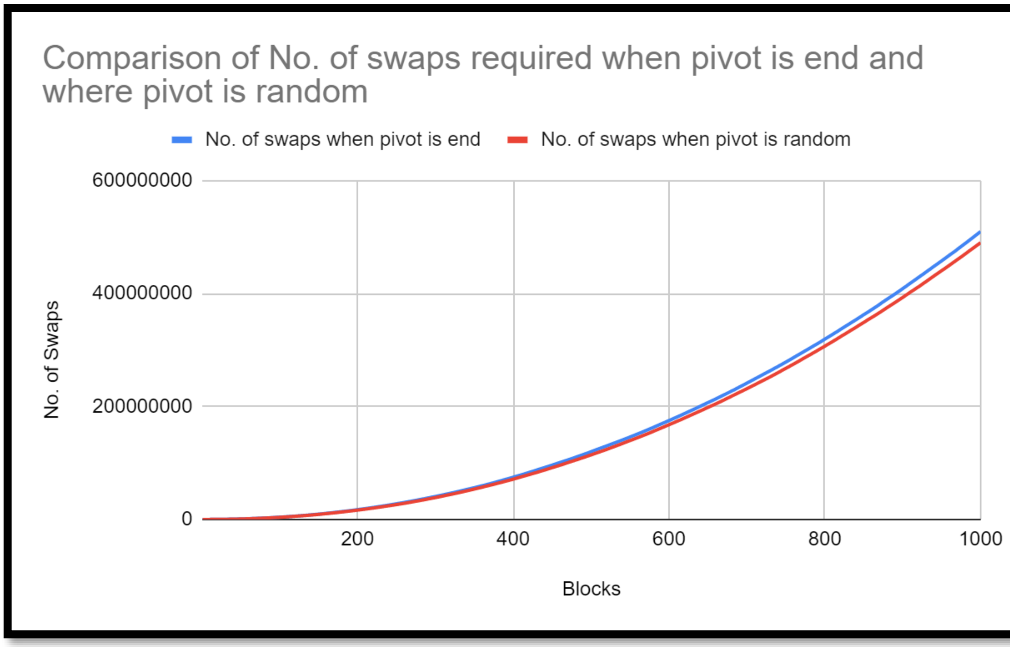
<tr><td></td><td>

We can see from this that fewer swaps are needed for a quick sort when the pivot is in a random position as opposed to when it is at the end.
The average number of swaps is over 500,000,000.
Throughout the entire execution, the number of swaps keeps rising.
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<tr><td>Conclusion:</td><td>Thus, we have provided observations for different pivots for quick sort algorithms.</td></tr>
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