VILNIUS GEDIMINAS TECHNICAL UNIVERSITY

FACULTY OF FUNDAMENTAL SCIENCES

DEPARTMENT OF INFORMATION SYSTEMS

ALGORITHMS AND DATA STRUCTURES

Homework No. 3

Prepared by: ITfuc-21 stud.

UFUK SAYLAN

Accepted by: lect. Urtė Radvilaitė

Vilnius, 2022

Task No. 13

Algorithms:

- Quicksort. Pivot – the median of the first, middle and last element.
- Mergesort.

The goal –

The goal is to determine and analyze the factors influencing the sorting speed of algorithms.

Tests:

1. Data – randomly generated numbers. Analyze 5 different sizes of data. Generate 5 sets of random numbers with each size of data and perform 10 tests on each of them.
2. Data – numbers generated in descending order. Analyze 5 different sizes of data. Perform at least 10 tests with the same size of data.

Testing environment. *(0,2 point)*

Parameters of a computer:

Asus Tuf laptop with a Ryzen 7 CPU, NVIDIA GeForce GTX 1650 graphics card, 16 GB of Ram Memory.

Programming language: C

Data structure used to store data: ARRAY

Other: The operating system (OS) running on the computer can also influence the performance and behavior of a program. In this case, I am using Ubuntu as the OS.

Study No. 1.

Evaluating the Performance of Quick Sort and Merge Sort on Random Data

Testing process. *(0,2 point)*

1. The first size of data selected – 5,000. Using a C program, numbers were generated 5 sets of random numbers and stored in different text files. They were stored in a array.
2. Each set of random numbers was sorted in both sorting algorithms 10 times. Sorting times were saved in a table and the average of all sorting times was calculated.
3. Steps 1 and 2 were repeated with the following sizes of data: 5,000; 50,000; 500,000; 5,000,000; 50,000,000.
4. The overall test results were presented in a graph and the results were analyzed.

Results.

The results are presented in tables and graphs.

The results presented in the table. *(0,6 point)*

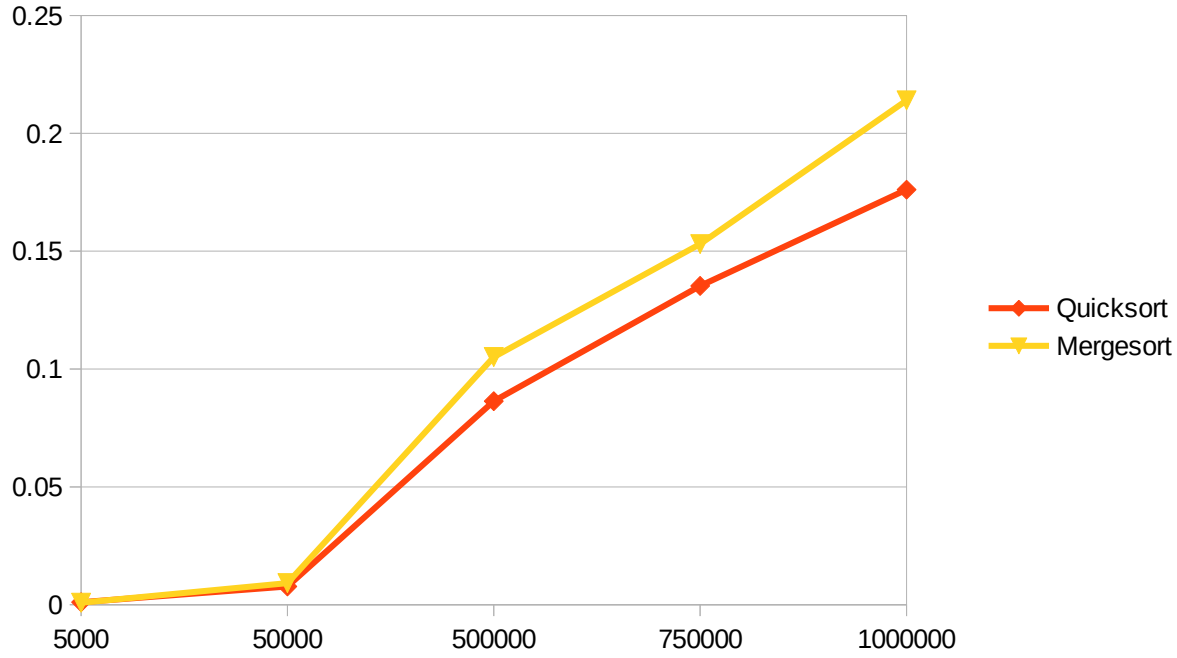
Table 1. Results when n=5,000;50,000;500,000;5,000,000;10,000,000

	Time of tests in Seconds										
Data list 1 n:5,000	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	Avg.
Quicksort	0.001475	0.001483	0.001372	0.001407	0.001499	0.000740	0.000740	0.000650	0.000613	0.000650	**0.001074**
Mergesort	0.001658	0.001060	0.000764	0.000709	0.000690	0.000682	0.000735	0.000694	0.000643	0.000735	**0.000837**
Data list 2 n:50,000	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	
Quicksort	0.007465	0.008161	0.007535	0.007884	0.007477	0.007874	0.007517	0.007902	0.008244	0.007475	**0.007753**
Mergesort	0.012735	0.008137	0.009072	0.009279	0.008969	0.009141	0.008948	0.008604	0.008053	0.008626	**0.009156**
Data list 3 n:500,000	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	
Quicksort	0.081283	0.081850	0.092144	0.099762	0.081821	0.088144	0.084925	0.089463	0.085043	0.079023	**0.086346**
Mergesort	0.115971	0.110757	0.095270	0.116394	0.119320	0.096058	0.095905	0.095516	0.108807	0.096898	**0.105090**
Data list 4 n:750,000	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	
Quicksort	0.120674	0.130712	0.147754	0.135213	0.123653	0.148836	0.149245	0.122883	0.148304	0.125301	**0.135257**
Mergesort	0.146477	0.178179	0.152651	0.152377	0.147918	0.147145	0.148102	0.147347	0.154569	0.155116	**0.152988**
Data list 5 n:1,000,000	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	
Quicksort	0.164418	0.165159	0.164071	0.177865	0.191831	0.183071	0.166402	0.204378	0.168716	0.175110	**0.176102**
Mergesort	0.246169	0.245776	0.214918	0.196808	0.239519	0.202795	0.197091	0.202148	0.198354	0.196184	**0.213976**

Table 2. General results.

The results presented in the graph. *(0,6 point)*

Figure 1. Random number sorting results.



Analysis of results.

Statement 1 – theoretical evaluation. *(0,2 point)*

The obtained testing results of Quicksort corresponds to theoretical evaluation.

The obtained testing results of Mergesort corresponds to theoretical evaluation.

Justification. ***(0,2 point – derivation of increase from theoretical estimate, 0,3 point – calculations, 0,3 point – analysis)***

Quicksort has a worst-case time complexity of O(n^2), although it has an average-case time complexity of O(n log n). This means that in the worst case, the algorithm will take O(n^2) time to sort an array of size n. However, the average-case time complexity is O(n log n), which means that on average, the algorithm will take O(n log n) time to sort an array of size n.

The QuickSort algorithm took 0.001074 seconds to sort an array of 5000 elements, according to our calculations. If we would considered the wors case, it should have taken 0.001074 * n^2 to complete other datas. We see it is not the case here. For comparison, it took 0.135257 seconds to sort

an array of 750,000 elements, which is much closer to the average-case performance of QuickSort than the worst-case performance. If it'd been worst case scenoria, it would take 0.001074 * 750,000^2 seconds, which is a lot larger than what we see.

<provide calculations>

<Here is an example when the theoretical estimate of the first algorithm is O(n^2). You need to look at the theoretical estimates of both of your algorithms and perform analogous calculations >

Theoretical estimate of an <algorithm> when data is random: O(n^2).

The size of data was increased twice each time, therefore:

$$\frac{(2n)^2}{n^2} = \frac{4n^2}{n^2} = 4.$$

Conclusion: Doubling the size of data should increase the sorting time by a factor of about 4.

Calculations with testing results:

$$\frac{avg.time(n=200\,000)}{avg.time(n=100\,000)} = \frac{3{,}98\,s}{1{,}10\,s} \approx 3{,}618.$$

$$\frac{avg.time(n=200\,000)}{avg.time(n=100\,000)} = \frac{xxxx\,s}{xxxx\,s} \approx \ldots\ldots$$

.....

.....

<Provide calculations for all sizes and examine whether the time always changed ~4 times. Is 3.618 close enough to 4 to be said to be within the theoretical estimate? If not, why?>

<Then you provide the calculations for the second algorithm>.

Statement 2 – speed comparison. *(0,2 point)*

Results showed that <algorithms> is faster than <algorithm> .....< describe when faster: always, only with specific size and so on>

Justification. *(0,3 point)*

.....
.....
.....
..... <based on theory (how algorithms work) explain why one algorithm is faster than another>

Statement 3 – <Think of it yourself. Based on the properties of algorithms, trends noticed >**.** *(0,2 point)*

.....
.....
.....

Justification. *(0,3 point)*

<base your statement on the operation of algorithms and theory >

.....
.....
.....

Study No. 2

Efficiency Comparison of Merge Sort and Quick Sort on Descending Order Data

Testing process. *(0,2 point)* <describe step by step what to do in the testing>

1. .....
2. .....
3. .....
4. .....

Results.

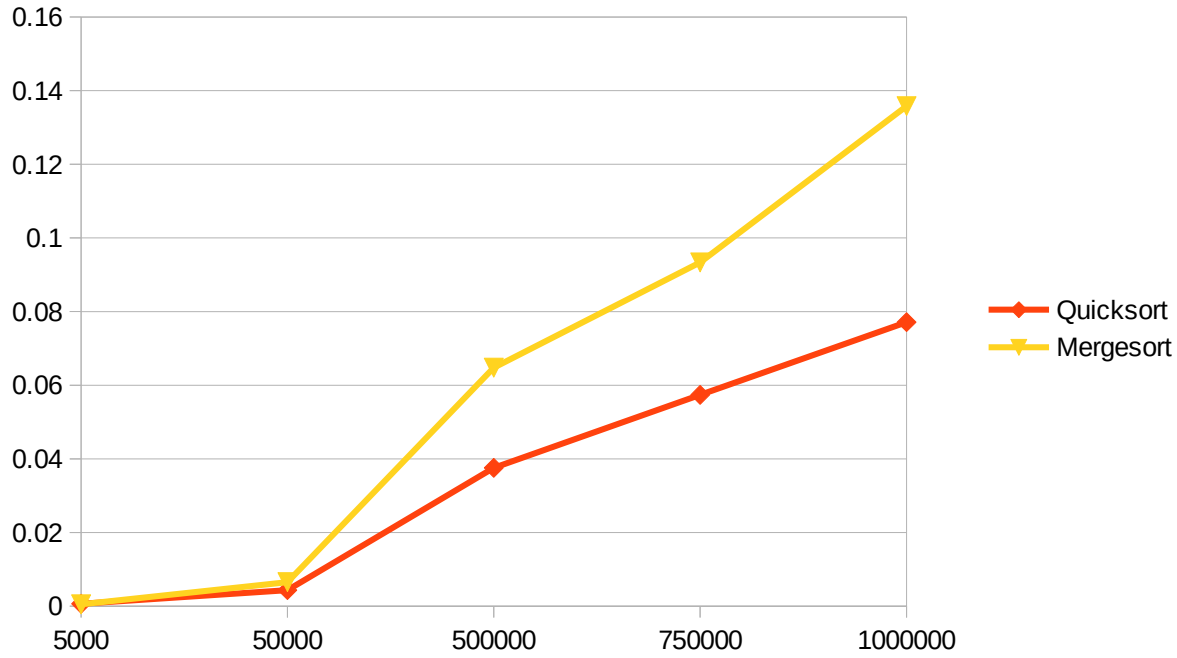
The results are presented in tables and graphs.

The results presented in the table. *(0,6 point)*

	Time of tests of descending data sets in Seconds										
Data list 1 n:5,000	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	Avg.
Quicksort	0.000862	0.000733	0.000738	0.000727	0.000732	0.000735	0.000738	0.000469	0.000400	0.000366	**0.000650**
Mergesort	0.000404	0.000397	0.000444	0.000496	0.000484	0.000509	0.000556	0.000568	0.000559	0.000555	**0.000497**
Data list 2 n:50,000	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	
Quicksort	0.003444	0.004412	0.003861	0.004389	0.004661	0.005083	0.005027	0.004683	0.004822	0.003277	**0.004366**
Mergesort	0.013563	0.005759	0.005816	0.005883	0.006265	0.005743	0.005766	0.005707	0.005743	0.005095	**0.006534**
Data list 3 n:500,000	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	
Quicksort	0.034779	0.035933	0.035933	0.034948	0.040549	0.042442	0.044040	0.037059	0.035094	0.034817	**0.037559**
Mergesort	0.058178	0.057837	0.060389	0.063925	0.067406	0.071071	0.070329	0.070420	0.059938	0.067990	**0.064748**
Data list 4 n:750,000	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	
Quicksort	0.052983	0.052585	0.054253	0.054960	0.064910	0.067057	0.059224	0.056095	0.057541	0.054103	**0.057371**
Mergesort	0.090180	0.088850	0.088486	0.089443	0.088879	0.088255	0.091546	0.088968	0.106205	0.112697	**0.093351**
Data list 5 n:1,000,000	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	
Quicksort	0.074144	0.089151	0.088498	0.092786	0.070539	0.072345	0.070858	0.070879	0.070934	0.071320	**0.077145**
Mergesort	0.117929	0.146225	0.145398	0.144719	0.133487	0.127474	0.146810	0.144861	0.131968	0.119075	**0.135795**

The results presented in the graph. *(0,6 point)*

***Figure 1**. Descending number sorting results.*



Analysis of results.

Statement 1 – theoretical evaluation. *(0,2 point)*

The obtained testing results of <1 algorithm> corresponds to/doesn't match theoretical evaluation.

The obtained testing results of <2 algorithm> corresponds to/doesn't match theoretical evaluation.

Justification. *(0,2 point – derivation of increase from theoretical estimate, 0,3 point – calculations, 0,3 point – analysis)*

<provide calculations and analysis>

<If the theoretical estimate is the same as for the first test, then proceed to the calculations of how time changes.>

Statement 2 – speed comparison. *(0,2 point)*

.....

.....

Justification. *(0,3 point)*

.....

.....

.....

..... <based on theory (how algorithms work) explain why one algorithm is faster than another>

Statement 3 –algorithm speed dependence on data set. *(0,2 point)*

Quicksort sorts the data in study of *Evaluating the Performance of Quick Sort and Merge Sort on Random Data* ***slower*** than *the data in the study of Efficiency Comparison of Merge Sort and Quick Sort on Descending Order Data*

Merge sorts the data in study of *Evaluating the Performance of Quick Sort and Merge Sort on Random Data* ***slower*** than *the data in the study of Efficiency Comparison of Merge Sort and Quick Sort on Descending Order Data*

Justification. *(0,3 point)*

Merge sort is a divide and conquer algorithm that works by dividing the input array into smaller subarrays, sorting those subarrays, and then merging them back together. The merge step of the algorithm is typically the most efficient part, because it involves combining two sorted arrays into a single sorted array in a single pass through the data.

In the case of an array that is already in descending order, the subarrays produced by the divide step will already be partially sorted, which means that the merge step can more efficiently combine them into a single sorted array. This will lead to faster overall runtime for merge sort on such arrays.

Quick sort does not generally perform better on arrays that are already partially sorted or in descending order. In fact, quick sort tends to perform worse on such arrays because the pivot selection process is less effective at partitioning the array into two balanced subarrays. However, our choice of pivot element was median. That’s why it is more likely to partition the array into two subarrays of approximately equal size.

General conclusions.

1. conclusion. *(0,3 point)*

   .....

2. conclusion. *(0,3 point)*

   .....

3. conclusion. *(0,3 point)*

   .....

<provide GENERALIZED conclusions of both studies>

ANNEXES.

Quicksort with 500,000 random numbers data:

```
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ g++ QuickSort1.c
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ ./a.out
 1.Test: Time taken by Quick sort: 0.081283 seconds
 2.Test: Time taken by Quick sort: 0.081850 seconds
 3.Test: Time taken by Quick sort: 0.092144 seconds
 4.Test: Time taken by Quick sort: 0.099762 seconds
 5.Test: Time taken by Quick sort: 0.081821 seconds
 6.Test: Time taken by Quick sort: 0.088144 seconds
 7.Test: Time taken by Quick sort: 0.084925 seconds
 8.Test: Time taken by Quick sort: 0.089463 seconds
 9.Test: Time taken by Quick sort: 0.085043 seconds
 10.Test: Time taken by Quick sort: 0.079023 seconds
 Average is 0.086346
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$
```

Quicksort with 50,000 random numbers data:

```
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ g++ QuickSort1.c
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ ./a.out
 1.Test: Time taken by Quick sort: 0.007465 seconds
 2.Test: Time taken by Quick sort: 0.008161 seconds
 3.Test: Time taken by Quick sort: 0.007535 seconds
 4.Test: Time taken by Quick sort: 0.007884 seconds
 5.Test: Time taken by Quick sort: 0.007477 seconds
 6.Test: Time taken by Quick sort: 0.007874 seconds
 7.Test: Time taken by Quick sort: 0.007517 seconds
 8.Test: Time taken by Quick sort: 0.007902 seconds
 9.Test: Time taken by Quick sort: 0.008244 seconds
 10.Test: Time taken by Quick sort: 0.007475 seconds
 Average is 0.007753
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$
```

Quicksort with 5,000 random numbers data:

```
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ g++ QuickSort1.c
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ ./a.out
 1.Test: Time taken by Quick sort: 0.001475 seconds
 2.Test: Time taken by Quick sort: 0.001483 seconds
 3.Test: Time taken by Quick sort: 0.001372 seconds
 4.Test: Time taken by Quick sort: 0.001407 seconds
 5.Test: Time taken by Quick sort: 0.001499 seconds
 6.Test: Time taken by Quick sort: 0.000740 seconds
 7.Test: Time taken by Quick sort: 0.000855 seconds
 8.Test: Time taken by Quick sort: 0.000650 seconds
 9.Test: Time taken by Quick sort: 0.000613 seconds
 10.Test: Time taken by Quick sort: 0.000650 seconds
 Average is 0.001074
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$
```

Mergesort with 5,000 random numbers data:

```
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ g++ MergeSort.c
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ ./a.out
 1.Test: Time taken by Merge sort: 0.001658 seconds
 2.Test: Time taken by Merge sort: 0.001060 seconds
 3.Test: Time taken by Merge sort: 0.000764 seconds
 4.Test: Time taken by Merge sort: 0.000709 seconds
 5.Test: Time taken by Merge sort: 0.000690 seconds
 6.Test: Time taken by Merge sort: 0.000682 seconds
 7.Test: Time taken by Merge sort: 0.000735 seconds
 8.Test: Time taken by Merge sort: 0.000694 seconds
 9.Test: Time taken by Merge sort: 0.000643 seconds
 10.Test: Time taken by Merge sort: 0.000735 seconds
 Average is 0.000837
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$
```

Mergesort with 50,000 random numbers data:

```
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ g++ MergeSort.c
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ ./a.out
 1.Test: Time taken by Merge sort: 0.012735 seconds
 2.Test: Time taken by Merge sort: 0.008137 seconds
 3.Test: Time taken by Merge sort: 0.009072 seconds
 4.Test: Time taken by Merge sort: 0.009279 seconds
 5.Test: Time taken by Merge sort: 0.008969 seconds
 6.Test: Time taken by Merge sort: 0.009141 seconds
 7.Test: Time taken by Merge sort: 0.008948 seconds
 8.Test: Time taken by Merge sort: 0.008604 seconds
 9.Test: Time taken by Merge sort: 0.008053 seconds
 10.Test: Time taken by Merge sort: 0.008626 seconds
 Average is 0.009156
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$
```

Mergesort with 500,000 random numbers data:

```
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ g++ MergeSort.c
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ ./a.out
 1.Test: Time taken by Merge sort: 0.115971 seconds
 2.Test: Time taken by Merge sort: 0.110757 seconds
 3.Test: Time taken by Merge sort: 0.095270 seconds
 4.Test: Time taken by Merge sort: 0.116394 seconds
 5.Test: Time taken by Merge sort: 0.119320 seconds
 6.Test: Time taken by Merge sort: 0.096058 seconds
 7.Test: Time taken by Merge sort: 0.095905 seconds
 8.Test: Time taken by Merge sort: 0.095516 seconds
 9.Test: Time taken by Merge sort: 0.108807 seconds
 10.Test: Time taken by Merge sort: 0.096898 seconds
 Average is 0.105090
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$
```

Mergesort with 750,000 random numbers data:

```
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ g++ MergeSort.c
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ ./a.out
 1.Test: Time taken by Merge sort: 0.146477 seconds
 2.Test: Time taken by Merge sort: 0.178179 seconds
 3.Test: Time taken by Merge sort: 0.152651 seconds
 4.Test: Time taken by Merge sort: 0.152377 seconds
 5.Test: Time taken by Merge sort: 0.147918 seconds
 6.Test: Time taken by Merge sort: 0.147145 seconds
 7.Test: Time taken by Merge sort: 0.148102 seconds
 8.Test: Time taken by Merge sort: 0.147347 seconds
 9.Test: Time taken by Merge sort: 0.154569 seconds
 10.Test: Time taken by Merge sort: 0.155116 seconds
 Average is 0.152988
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$
```

a

Mergesort with 1,000,000 random numbers data:

```
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ g++ MergeSort.c
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ ./a.out
1.Test: Time taken by Merge sort: 0.246169 seconds
2.Test: Time taken by Merge sort: 0.245776 seconds
3.Test: Time taken by Merge sort: 0.214918 seconds
4.Test: Time taken by Merge sort: 0.196808 seconds
5.Test: Time taken by Merge sort: 0.239519 seconds
6.Test: Time taken by Merge sort: 0.202795 seconds
7.Test: Time taken by Merge sort: 0.197091 seconds
8.Test: Time taken by Merge sort: 0.202148 seconds
9.Test: Time taken by Merge sort: 0.198354 seconds
10.Test: Time taken by Merge sort: 0.196184 seconds
Average is 0.213976
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$
```

Quicksort with 750,000 random numbers data:

```
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ g++ QuickSort1.c
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ ./a.out
1.Test: Time taken by Quick sort: 0.120674 seconds
2.Test: Time taken by Quick sort: 0.130712 seconds
3.Test: Time taken by Quick sort: 0.147754 seconds
4.Test: Time taken by Quick sort: 0.135213 seconds
5.Test: Time taken by Quick sort: 0.123653 seconds
6.Test: Time taken by Quick sort: 0.148836 seconds
7.Test: Time taken by Quick sort: 0.149245 seconds
8.Test: Time taken by Quick sort: 0.122883 seconds
9.Test: Time taken by Quick sort: 0.148304 seconds
10.Test: Time taken by Quick sort: 0.125301 seconds
Average is 0.135257
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$
```

Quicksort with 1,000,000 random numbers data:

```
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ g++ QuickSort1.c
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ ./a.out
1.Test: Time taken by Quick sort: 0.164418 seconds
2.Test: Time taken by Quick sort: 0.165159 seconds
3.Test: Time taken by Quick sort: 0.164071 seconds
4.Test: Time taken by Quick sort: 0.177865 seconds
5.Test: Time taken by Quick sort: 0.191831 seconds
6.Test: Time taken by Quick sort: 0.183071 seconds
7.Test: Time taken by Quick sort: 0.166402 seconds
8.Test: Time taken by Quick sort: 0.204378 seconds
9.Test: Time taken by Quick sort: 0.168716 seconds
10.Test: Time taken by Quick sort: 0.175110 seconds
Average is 0.176102
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$
```

Quicksort with 1,000,000 descending numbers data:

```
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ g++ QuickSort1.c
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ ./a.out
 1.Test: Time taken by Quick sort: 0.074144 seconds
 2.Test: Time taken by Quick sort: 0.089151 seconds
 3.Test: Time taken by Quick sort: 0.088498 seconds
 4.Test: Time taken by Quick sort: 0.092786 seconds
 5.Test: Time taken by Quick sort: 0.070539 seconds
 6.Test: Time taken by Quick sort: 0.072345 seconds
 7.Test: Time taken by Quick sort: 0.070858 seconds
 8.Test: Time taken by Quick sort: 0.070879 seconds
 9.Test: Time taken by Quick sort: 0.070934 seconds
 10.Test: Time taken by Quick sort: 0.071320 seconds
 Average is 0.077145
```

Mergesort with 1,000,000 descending numbers data:

```
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ g++ MergeSort.c
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ ./a.out
 1.Test: Time taken by Merge sort: 0.117929 seconds
 2.Test: Time taken by Merge sort: 0.146225 seconds
 3.Test: Time taken by Merge sort: 0.145398 seconds
 4.Test: Time taken by Merge sort: 0.144719 seconds
 5.Test: Time taken by Merge sort: 0.133487 seconds
 6.Test: Time taken by Merge sort: 0.127474 seconds
 7.Test: Time taken by Merge sort: 0.146810 seconds
 8.Test: Time taken by Merge sort: 0.144861 seconds
 9.Test: Time taken by Merge sort: 0.131968 seconds
 10.Test: Time taken by Merge sort: 0.119075 seconds
 Average is 0.135795
```

Mergesort with 750,000 descending numbers data:

```
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ g++ MergeSort.c
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ ./a.out
 1.Test: Time taken by Merge sort: 0.090180 seconds
 2.Test: Time taken by Merge sort: 0.088850 seconds
 3.Test: Time taken by Merge sort: 0.088486 seconds
 4.Test: Time taken by Merge sort: 0.089443 seconds
 5.Test: Time taken by Merge sort: 0.088879 seconds
 6.Test: Time taken by Merge sort: 0.088255 seconds
 7.Test: Time taken by Merge sort: 0.091546 seconds
 8.Test: Time taken by Merge sort: 0.088968 seconds
 9.Test: Time taken by Merge sort: 0.106205 seconds
 10.Test: Time taken by Merge sort: 0.112697 seconds
 Average is 0.093351
```

Quicksort with 750,000 descending numbers data:

```
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ g++ QuickSort1.c
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ ./a.out
 1.Test: Time taken by Quick sort: 0.052983 seconds
 2.Test: Time taken by Quick sort: 0.052585 seconds
 3.Test: Time taken by Quick sort: 0.054253 seconds
 4.Test: Time taken by Quick sort: 0.054960 seconds
 5.Test: Time taken by Quick sort: 0.064910 seconds
 6.Test: Time taken by Quick sort: 0.067057 seconds
 7.Test: Time taken by Quick sort: 0.059224 seconds
 8.Test: Time taken by Quick sort: 0.056095 seconds
 9.Test: Time taken by Quick sort: 0.057541 seconds
 10.Test: Time taken by Quick sort: 0.054103 seconds
 Average is 0.057371
```

Quicksort with 500,000 descending numbers data:

```
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ g++ QuickSort1.c
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ ./a.out
 1.Test: Time taken by Quick sort: 0.034779 seconds
 2.Test: Time taken by Quick sort: 0.035933 seconds
 3.Test: Time taken by Quick sort: 0.035933 seconds
 4.Test: Time taken by Quick sort: 0.034948 seconds
 5.Test: Time taken by Quick sort: 0.040549 seconds
 6.Test: Time taken by Quick sort: 0.042442 seconds
 7.Test: Time taken by Quick sort: 0.044040 seconds
 8.Test: Time taken by Quick sort: 0.037059 seconds
 9.Test: Time taken by Quick sort: 0.035094 seconds
 10.Test: Time taken by Quick sort: 0.034817 seconds
 Average is 0.037559
```

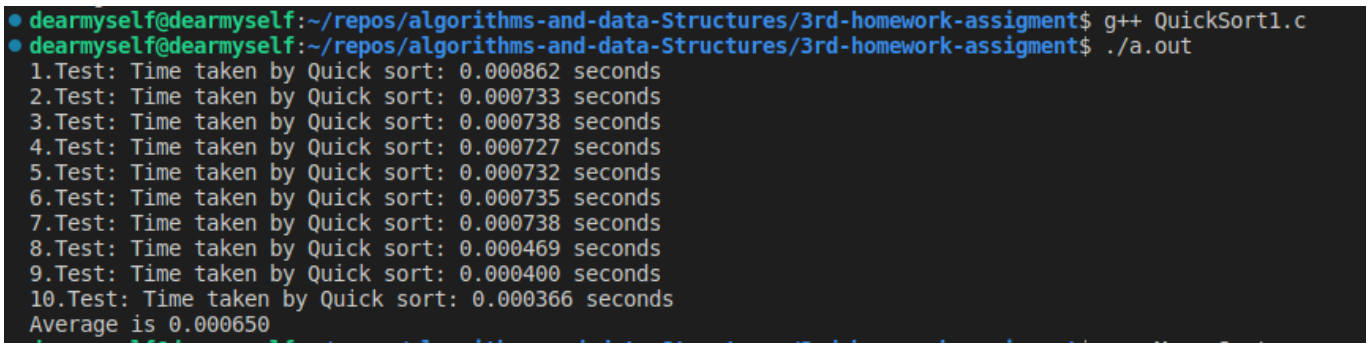
Mergesort with 500,000 descending numbers data:

```
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ g++ MergeSort.c
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ ./a.out
 1.Test: Time taken by Merge sort: 0.058178 seconds
 2.Test: Time taken by Merge sort: 0.057837 seconds
 3.Test: Time taken by Merge sort: 0.060389 seconds
 4.Test: Time taken by Merge sort: 0.063925 seconds
 5.Test: Time taken by Merge sort: 0.067406 seconds
 6.Test: Time taken by Merge sort: 0.071071 seconds
 7.Test: Time taken by Merge sort: 0.070329 seconds
 8.Test: Time taken by Merge sort: 0.070420 seconds
 9.Test: Time taken by Merge sort: 0.059938 seconds
 10.Test: Time taken by Merge sort: 0.067990 seconds
 Average is 0.064748
```

Mergesort with 50,000 descending numbers data:

```
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ g++ MergeSort.c
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ ./a.out
 1.Test: Time taken by Merge sort: 0.013563 seconds
 2.Test: Time taken by Merge sort: 0.005759 seconds
 3.Test: Time taken by Merge sort: 0.005816 seconds
 4.Test: Time taken by Merge sort: 0.005883 seconds
 5.Test: Time taken by Merge sort: 0.006265 seconds
 6.Test: Time taken by Merge sort: 0.005743 seconds
 7.Test: Time taken by Merge sort: 0.005766 seconds
 8.Test: Time taken by Merge sort: 0.005707 seconds
 9.Test: Time taken by Merge sort: 0.005743 seconds
 10.Test: Time taken by Merge sort: 0.005095 seconds
 Average is 0.006534
```

Quicksort with 5,000 descending numbers data:


dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ g++ QuickSort1.c
dearmyself@dearmyself:~/repos/algorithms-and-data-Structures/3rd-homework-assigment$ ./a.out
1.Test: Time taken by Quick sort: 0.000862 seconds
2.Test: Time taken by Quick sort: 0.000733 seconds
3.Test: Time taken by Quick sort: 0.000738 seconds
4.Test: Time taken by Quick sort: 0.000727 seconds
5.Test: Time taken by Quick sort: 0.000732 seconds
6.Test: Time taken by Quick sort: 0.000735 seconds
7.Test: Time taken by Quick sort: 0.000738 seconds
8.Test: Time taken by Quick sort: 0.000469 seconds
9.Test: Time taken by Quick sort: 0.000400 seconds
10.Test: Time taken by Quick sort: 0.000366 seconds
Average is 0.000650