Bilkent University
CS202 - HW1

Section 3

Hacı Çakın

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Question 1

1.a)

$$f(n) = 5n^3 + 4n^2 + 10$$

$$O(n^4)$$

When n >= 1, c=19 so;

$$5n^3 + 4n^2 + 10 <= 19n^4$$

1.b) [24, 8, 51, 28, 20, 29, 21, 17, 38, 27]

-Insertion Sort

24	8	51	28	20	29	21	17	38	27

Compare 24 with 8 and change them

8	24	51	28	20	29	21	17	38	27

Compare 24 with 51

8	24	51	28	20	29	21	17	38	27

Compare 51 with 28 and to find correct location for 28 compare 28 with 24

8	24	28	51	20	29	21	17	38	27

Compare 51 with 20 and to find correct location for 20 compare 20 with 28,24,8 respectively

8	20	24	28	51	29	21	17	38	27

Compare 51 with 29 and to find correct location for 29, compare 29 with 28

8	20	24	28	29	51	21	17	38	27

Compare 51 with 21 and to find correct location for 21 compare 21 with 29,28,24,20 respectively

8	20	21	24	28	29	51	17	38	27

Compare 51 with 17 and to find correct location for 17 compare 17 with 29,28,24,21,20,8 respectively

8	17	20	21	24	28	29	51	38	27

Compare 51 with 38 and to find correct location for 38 compare 38 with 29

8	17	20	21	24	28	29	38	51	27

Compare 51 with 27 and to find correct location for 27 compare 27 with 38,29,28,24 respectively

8	17	20	21	24	27	28	39	38	51

Sorted!

-Bubble Sort

24	8	51	28	20	29	21	17	38	27

8	24	51	28	20	29	21	17	38	27

8	24	51	28	20	29	21	17	38	27

8	24	28	51	20	29	21	17	38	27

8	24	28	20	51	29	21	17	38	27

8	24	28	20	29	51	21	17	38	27

8	24	28	20	29	21	51	17	38	27

8	24	28	20	29	21	17	51	38	27

8	24	28	20	29	21	17	38	51	27

8	24	28	20	29	21	17	38	27	51

8	24	28	20	29	21	17	38	27	51

8	24	28	20	29	21	17	38	27	51

8	24	28	20	29	21	17	38	27	51

8	24	20	28	29	21	17	38	27	51

8	24	20	28	29	21	17	38	27	51

8	24	20	28	21	29	17	38	27	51

8	24	20	28	21	17	29	38	27	51

8	24	20	28	21	17	29	38	27	51

8	24	20	28	21	17	29	27	38	51

8	24	20	28	21	17	29	27	38	51

8	24	20	28	21	17	29	27	38	51

8	20	24	28	21	17	29	27	38	51

8	20	24	28	21	17	29	27	38	51

8	20	24	21	28	17	29	27	38	51

8	20	24	21	17	28	29	27	38	51

8	20	24	21	17	28	29	27	38	51

8	20	24	21	17	28	27	29	38	51

8	20	24	21	17	28	27	29	38	51

8	20	24	21	17	28	27	29	38	51

8	20	24	21	17	28	27	29	38	51

8	20	24	21	17	28	27	29	38	51

8	20	21	24	17	28	27	29	38	51

8	20	21	17	24	28	27	29	38	51

8	20	21	17	24	28	27	29	38	51

8	20	21	17	24	27	28	29	38	51

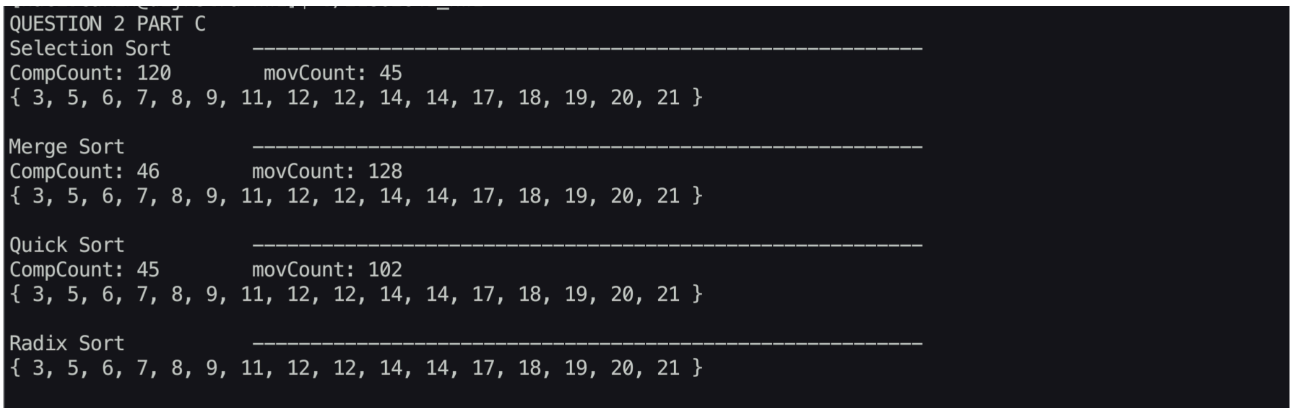
8	20	21	17	24	27	28	29	38	51

8	20	21	17	24	27	28	29	38	51

8	20	21	17	24	27	28	29	38	51
8	20	21	17	24	27	28	29	38	51
8	20	21	17	24	27	28	29	38	51
8	20	17	21	24	27	28	29	38	51
8	20	17	21	24	27	28	29	38	51
8	20	17	21	24	27	28	29	38	51
8	20	17	21	24	27	28	29	38	51
8	20	17	21	24	27	28	29	38	51
8	20	17	21	24	27	28	29	38	51

8	20	17	21	24	27	28	29	38	51
8	20	17	21	24	27	28	29	38	51
8	17	20	21	24	27	28	29	38	51
8	20	17	21	24	27	28	29	38	51
8	20	17	21	24	27	28	29	38	51
8	20	17	21	24	27	28	29	38	51
8	20	17	21	24	27	28	29	38	51
8	20	17	21	24	27	28	29	38	51
8	20	17	21	24	27	28	29	38	51

Question 2



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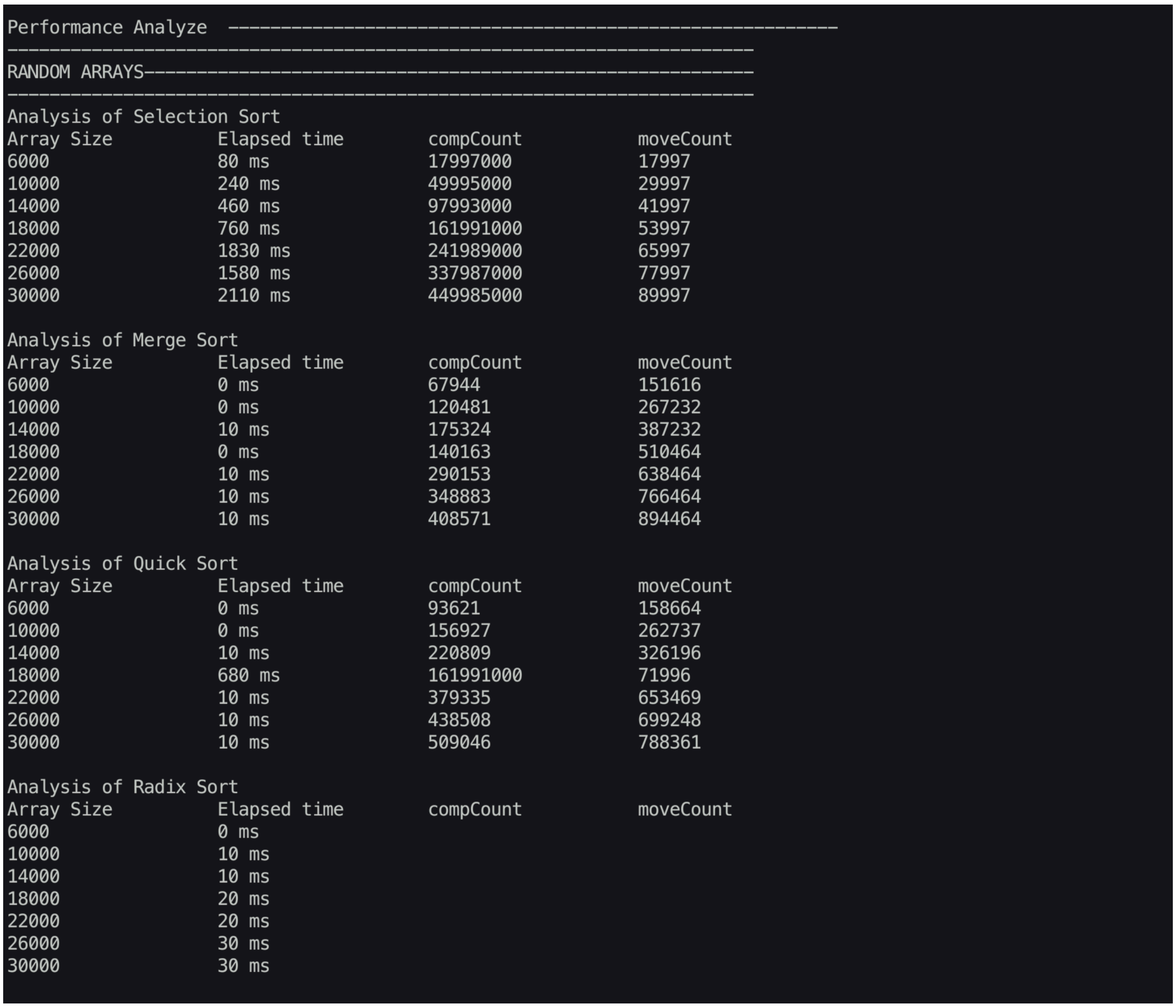
QUESTION 2 PART C
Selection Sort      ----------------------------------------------------------
CompCount: 120       movCount: 45
{ 3, 5, 6, 7, 8, 9, 11, 12, 12, 14, 14, 17, 18, 19, 20, 21 }

Merge Sort          ----------------------------------------------------------
CompCount: 46       movCount: 128
{ 3, 5, 6, 7, 8, 9, 11, 12, 12, 14, 14, 17, 18, 19, 20, 21 }

Quick Sort          ----------------------------------------------------------
CompCount: 45       movCount: 102
{ 3, 5, 6, 7, 8, 9, 11, 12, 12, 14, 14, 17, 18, 19, 20, 21 }

Radix Sort          ----------------------------------------------------------
{ 3, 5, 6, 7, 8, 9, 11, 12, 12, 14, 14, 17, 18, 19, 20, 21 }
```



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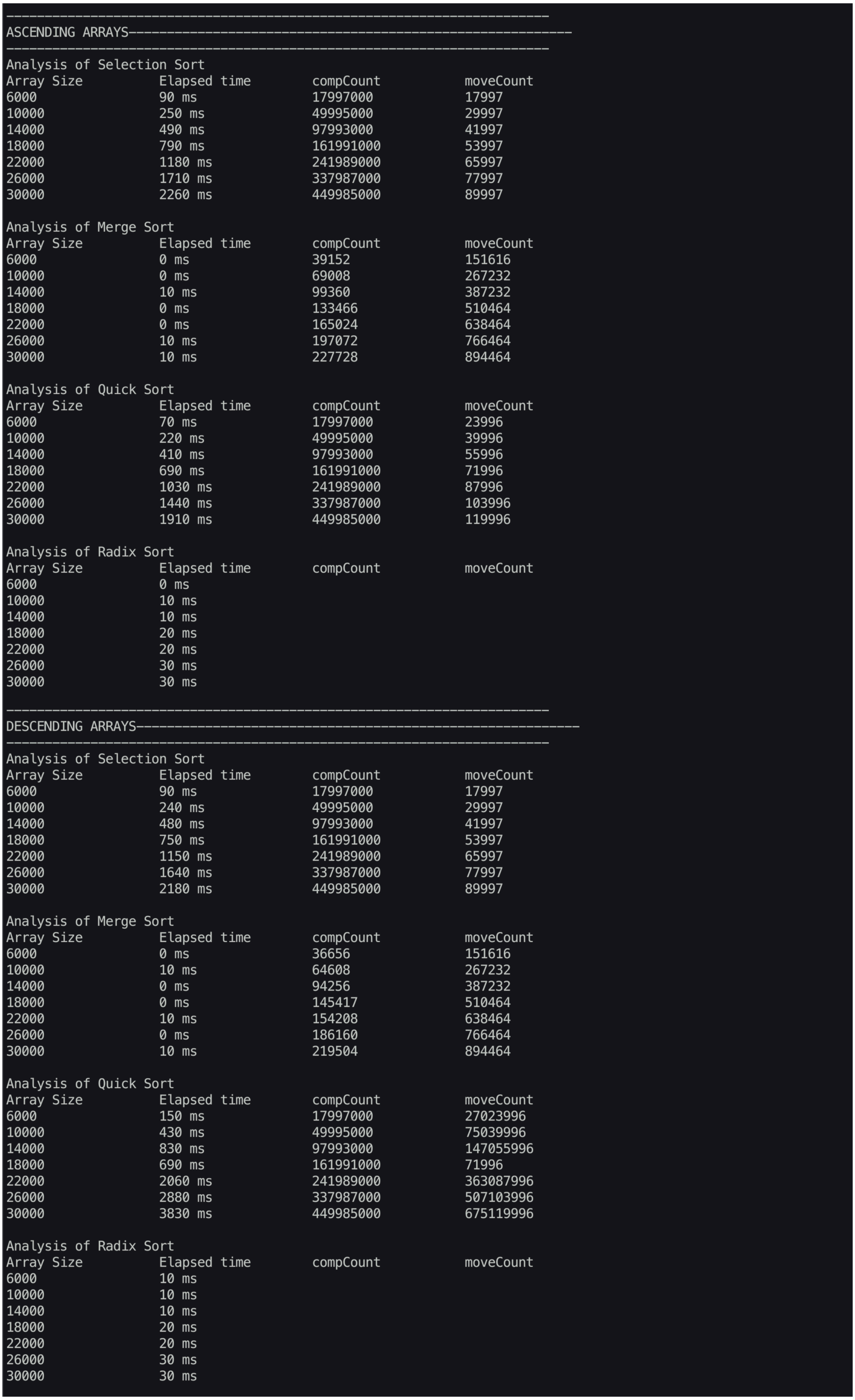
Performance Analyze  ----------------------------------------------------------
----------------------------------------------------------------------
RANDOM ARRAYS-------------------------------------------------------------
----------------------------------------------------------------------
Analysis of Selection Sort
Array Size          Elapsed time        compCount           moveCount
6000                80 ms               17997000            17997
10000               240 ms              49995000            29997
14000               460 ms              97993000            41997
18000               760 ms              161991000           53997
22000               1830 ms             241989000           65997
26000               1580 ms             337987000           77997
30000               2110 ms             449985000           89997

Analysis of Merge Sort
Array Size          Elapsed time        compCount           moveCount
6000                0 ms                67944               151616
10000               0 ms                120481              267232
14000               10 ms               175324              387232
18000               0 ms                140163              510464
22000               10 ms               290153              638464
26000               10 ms               348883              766464
30000               10 ms               408571              894464

Analysis of Quick Sort
Array Size          Elapsed time        compCount           moveCount
6000                0 ms                93621               158664
10000               0 ms                156927              262737
14000               10 ms               220809              326196
18000               680 ms              161991000           71996
22000               10 ms               379335              653469
26000               10 ms               438508              699248
30000               10 ms               509046              788361

Analysis of Radix Sort
Array Size          Elapsed time        compCount           moveCount
6000                0 ms
10000               10 ms
14000               10 ms
18000               20 ms
22000               20 ms
26000               30 ms
30000               30 ms
```



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-----------------------------------------------------------------------
ASCENDING ARRAYS-----------------------------------------------------------
-----------------------------------------------------------------------
Analysis of Selection Sort
Array Size          Elapsed time        compCount           moveCount
6000                90 ms               17997000            17997
10000               250 ms              49995000            29997
14000               490 ms              97993000            41997
18000               790 ms              161991000           53997
22000               1180 ms             241989000           65997
26000               1710 ms             337987000           77997
30000               2260 ms             449985000           89997

Analysis of Merge Sort
Array Size          Elapsed time        compCount           moveCount
6000                0 ms                39152               151616
10000               0 ms                69008               267232
14000               10 ms               99360               387232
18000               0 ms                133466              510464
22000               0 ms                165024              638464
26000               10 ms               197072              766464
30000               10 ms               227728              894464

Analysis of Quick Sort
Array Size          Elapsed time        compCount           moveCount
6000                70 ms               17997000            23996
10000               220 ms              49995000            39996
14000               410 ms              97993000            55996
18000               690 ms              161991000           71996
22000               1030 ms             241989000           87996
26000               1440 ms             337987000           103996
30000               1910 ms             449985000           119996

Analysis of Radix Sort
Array Size          Elapsed time        compCount           moveCount
6000                0 ms
10000               10 ms
14000               10 ms
18000               20 ms
22000               20 ms
26000               30 ms
30000               30 ms

-----------------------------------------------------------------------
DESCENDING ARRAYS-----------------------------------------------------------
-----------------------------------------------------------------------
Analysis of Selection Sort
Array Size          Elapsed time        compCount           moveCount
6000                90 ms               17997000            17997
10000               240 ms              49995000            29997
14000               480 ms              97993000            41997
18000               750 ms              161991000           53997
22000               1150 ms             241989000           65997
26000               1640 ms             337987000           77997
30000               2180 ms             449985000           89997

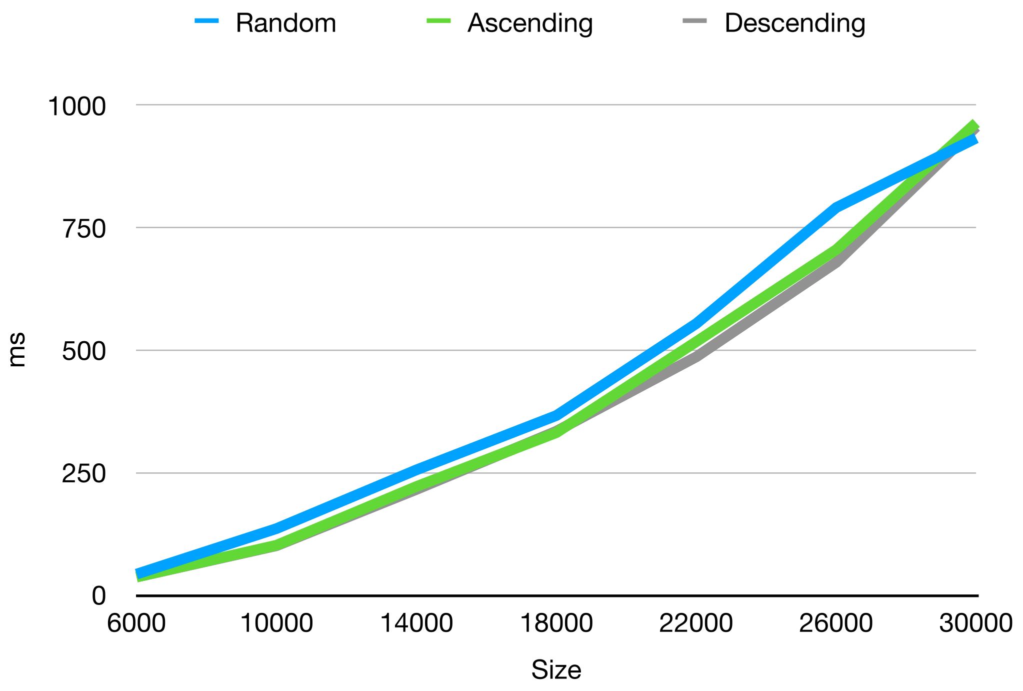
Analysis of Merge Sort
Array Size          Elapsed time        compCount           moveCount
6000                0 ms                36656               151616
10000               10 ms               64608               267232
14000               0 ms                94256               387232
18000               0 ms                145417              510464
22000               10 ms               154208              638464
26000               0 ms                186160              766464
30000               10 ms               219504              894464

Analysis of Quick Sort
Array Size          Elapsed time        compCount           moveCount
6000                150 ms              17997000            27023996
10000               430 ms              49995000            75039996
14000               830 ms              97993000            147055996
18000               690 ms              161991000           71996
22000               2060 ms             241989000           363087996
26000               2880 ms             337987000           507103996
30000               3830 ms             449985000           675119996

Analysis of Radix Sort
Array Size          Elapsed time        compCount           moveCount
6000                10 ms
10000               10 ms
14000               10 ms
18000               20 ms
22000               20 ms
26000               30 ms
30000               30 ms
```

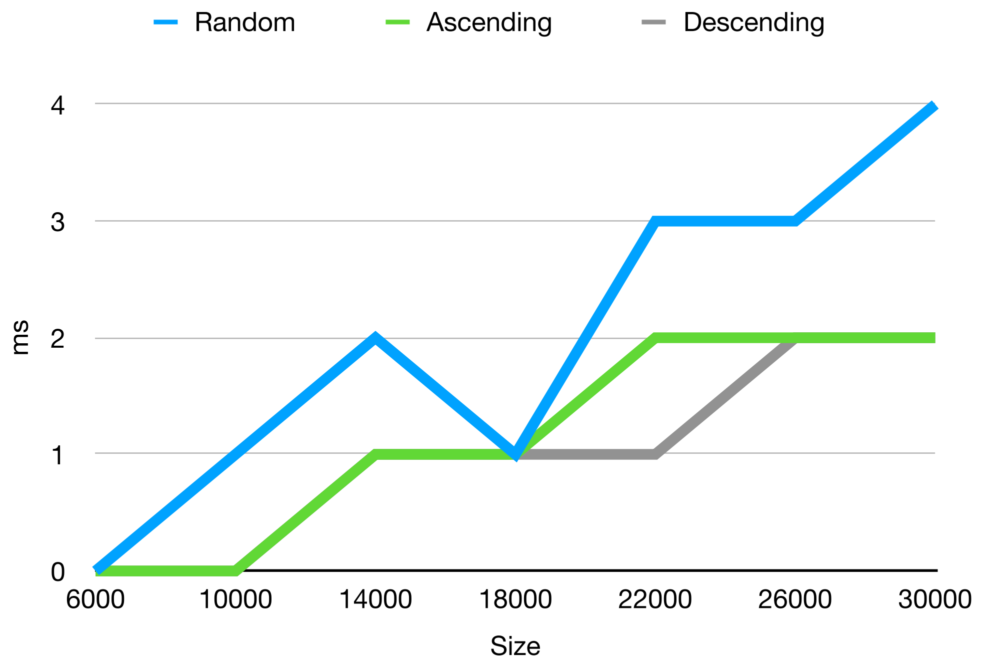
Question 3

3.a) Selection Sort



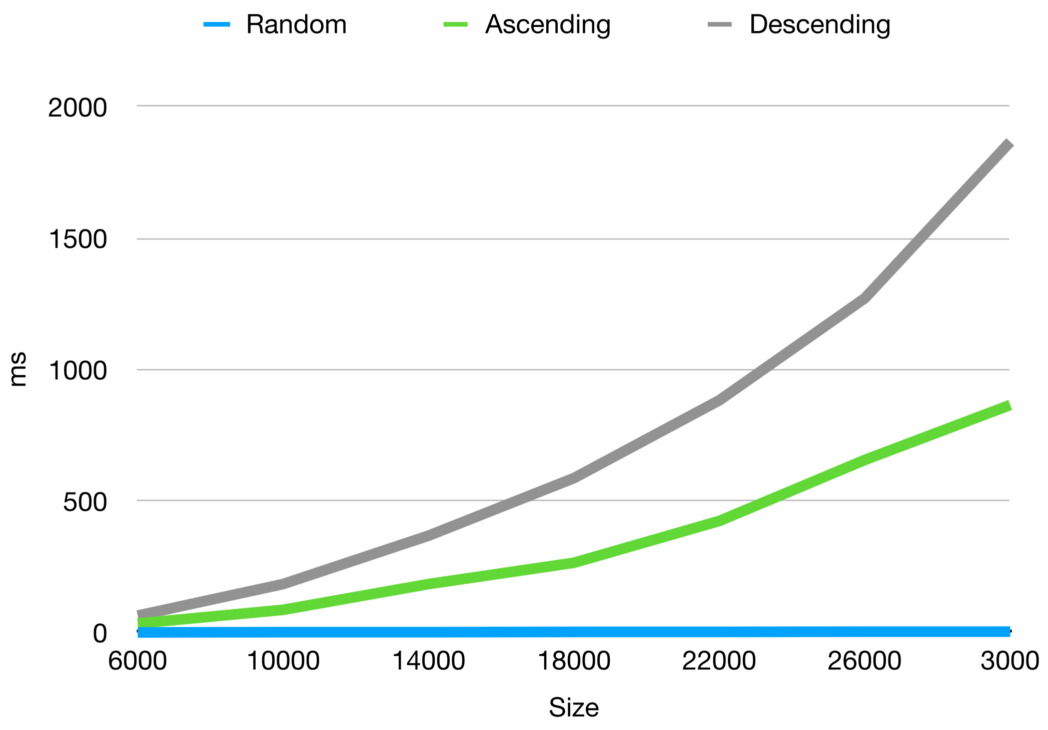
Analysis of Selection Sort: Theoretically selection sort has O(n^2) time complexity for each case(worst, best, average). In the experimental result it is parallel to what expected is. This means that in selection sort, the orientation of data is not that important. The reason of this is that for each element in array, we check whole array. Therefore, independent from the sorted or not, it gives same big-o.

3.b) Merge Sort



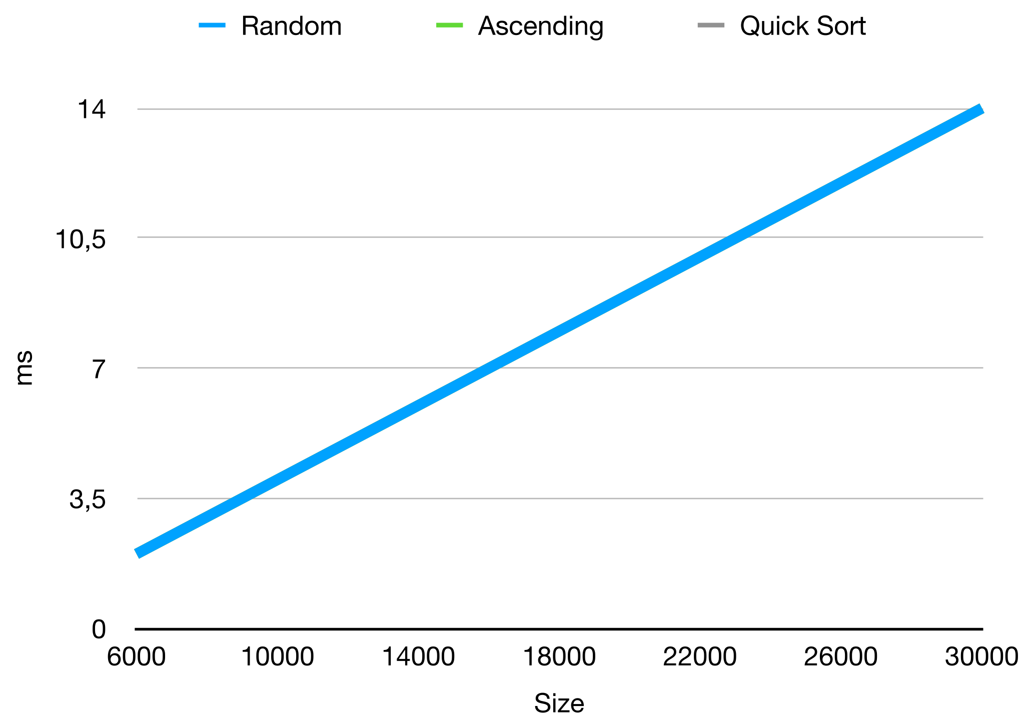
Analysis of Merge Sort: As it is happened in selection sort, merge sort also has O(n*logn) for each situation(worst, best, average). According to theoretical expectations, experimental results are should be parallel which is occurred. Therefore, the behavior of result is same with what I expect.

3.c) Quick Sort



Analysis of Merge Sort: For theoretical, in merge sort; worst case has O(n^2), best case has O(n*logn), average has O(n*logn). Because we order the array in ascending order, descending array is the worst case(most function call happens in this one). The important point is pivot. We choose pivot as a first index, therefore descending one takes much more time.

3.d) Radix Sort



Analysis of Radix Sort: In theoretical, radix sort has O(n). As experimental what I found is parallel to this expectation. In radix sort, independent from the sorted or not, each step is applied(finding digits, order according the digit, repeat same process). Therefore, it is not important whether array is sorted or not for the radix sort.