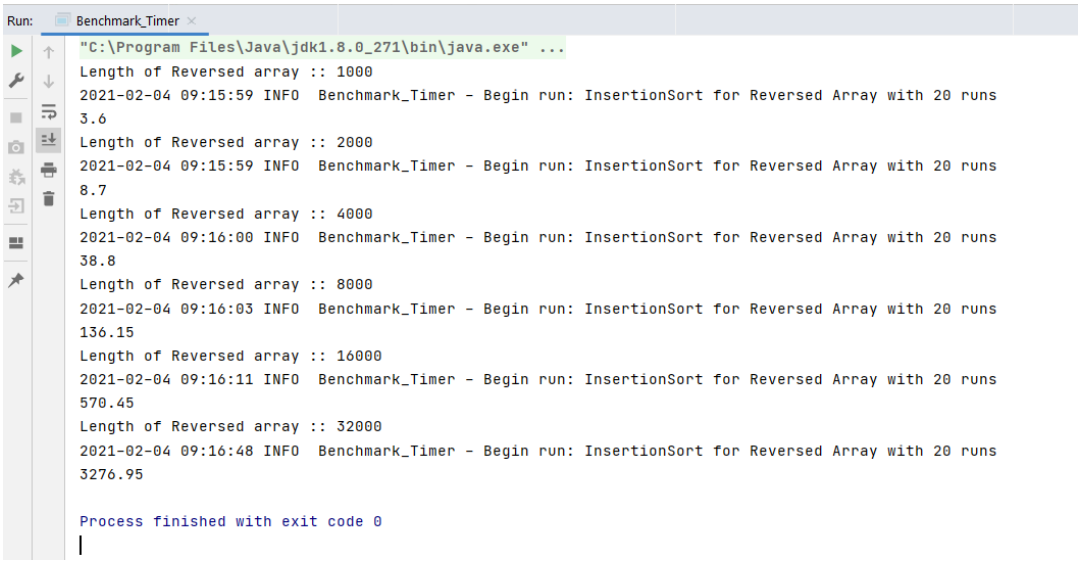
Aishwarya Ajit Deshpande - NUID 001003135

Program Structures & Algorithms
Spring 2021
Assignment No. 02

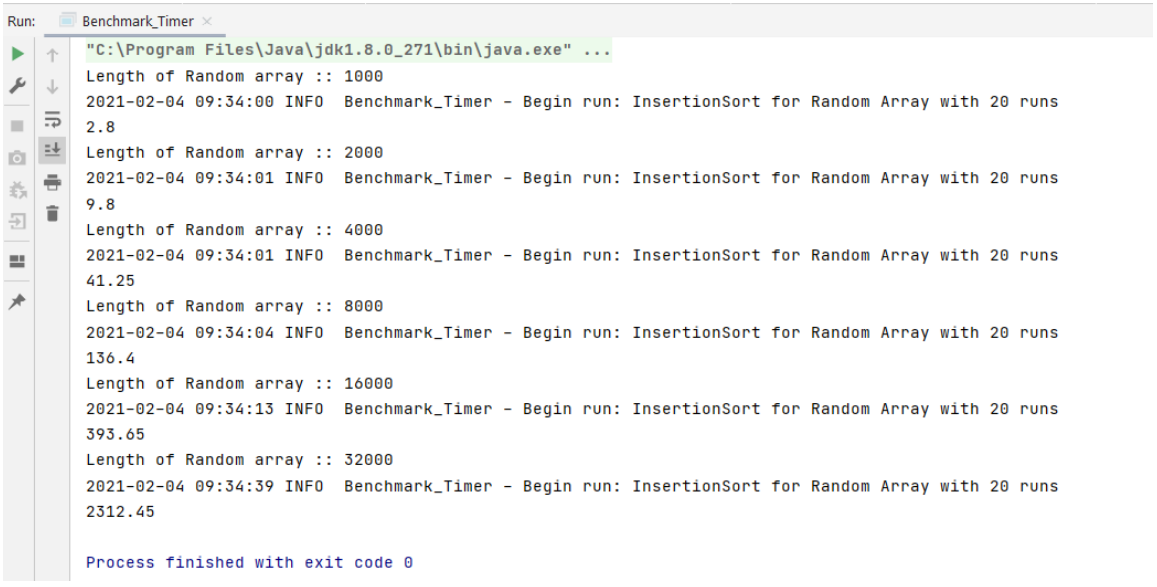
- ## Task
  1. To implement three methods of a class called Timer. Timer is invoked from a class called Benchmark_Timerwhich implements the Benchmark interface.
  2. Implement InsertionSort and run unit tests in InsertionSortTest.
  3. Implement a main program to run the following benchmarks: measure the running times of this sort, using four different initial array ordering situations: random, ordered, partially ordered and reverse-ordered. Use the doubling method for choosing n and test for at least five values of n. Draw any conclusions from your observations regarding the order of growth.

- ## Output

1. Reversed Array



2. Random Array



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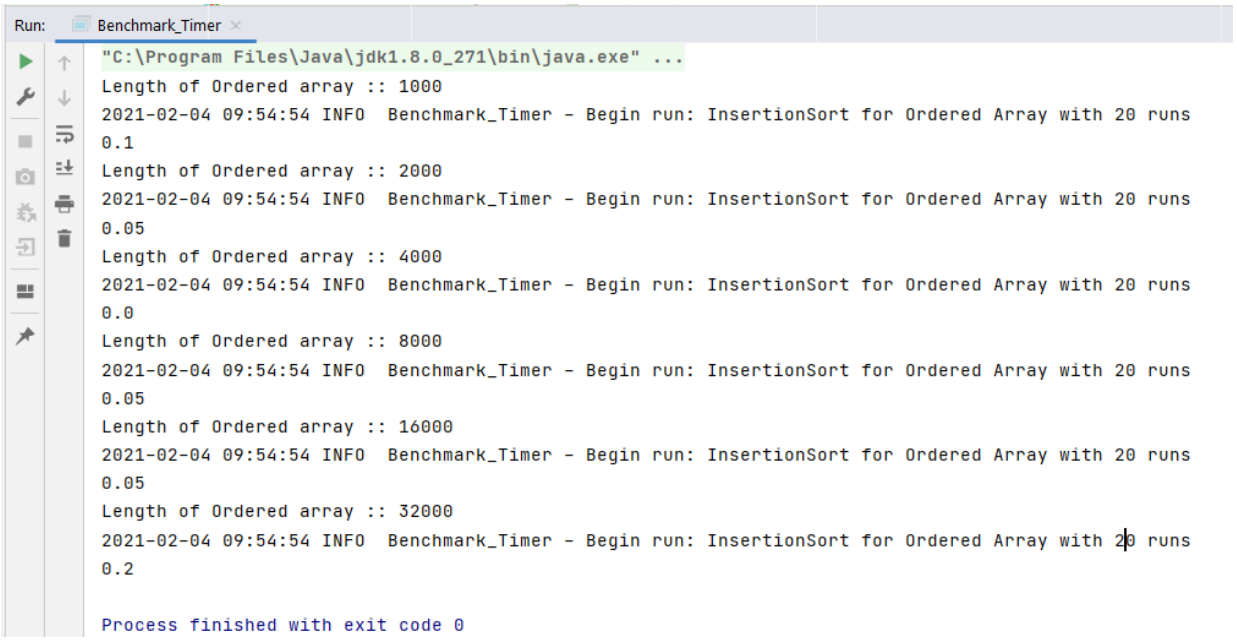
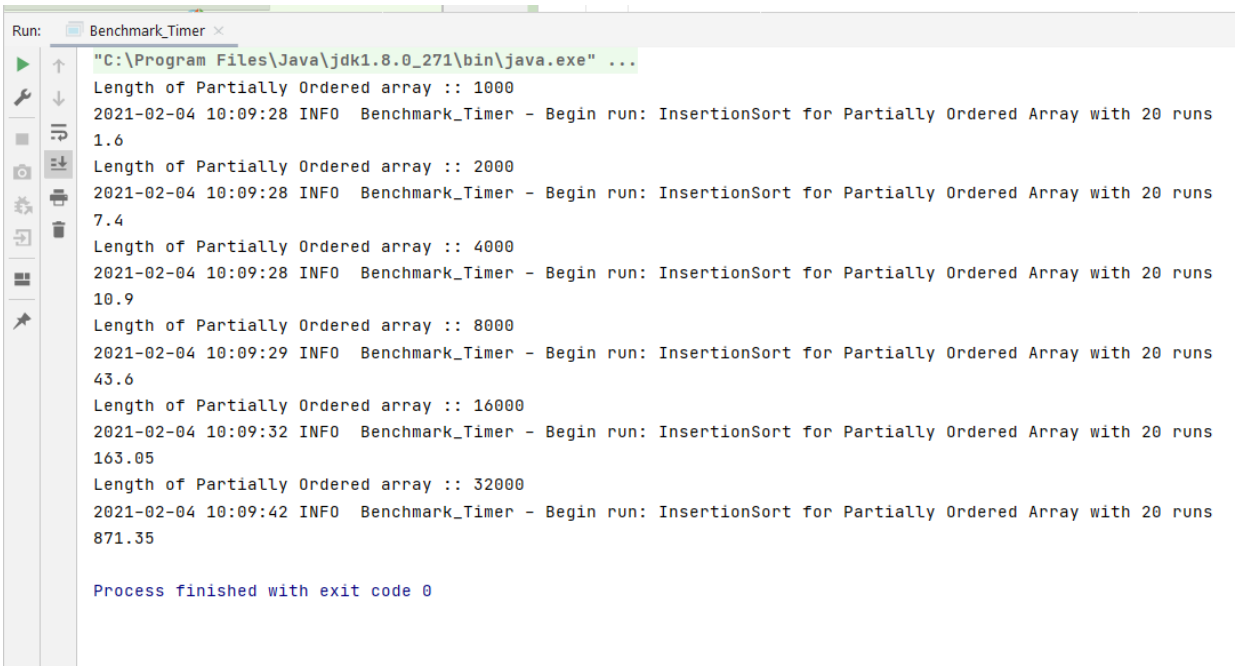
3. Ordered Array



4. Partially Ordered Array



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● Conclusion:

From the experiments carried out, it was observed for the different array types as:

Array Type	Order of Growth	Type of Analysis
Ordered Array	O(N)	Best Case
Partially Ordered Array	$O(N^2)$	Average Case
Random Array	$O(N^2)$	Worst Case
Reverse Array	$O(N^2)$	Worst Case

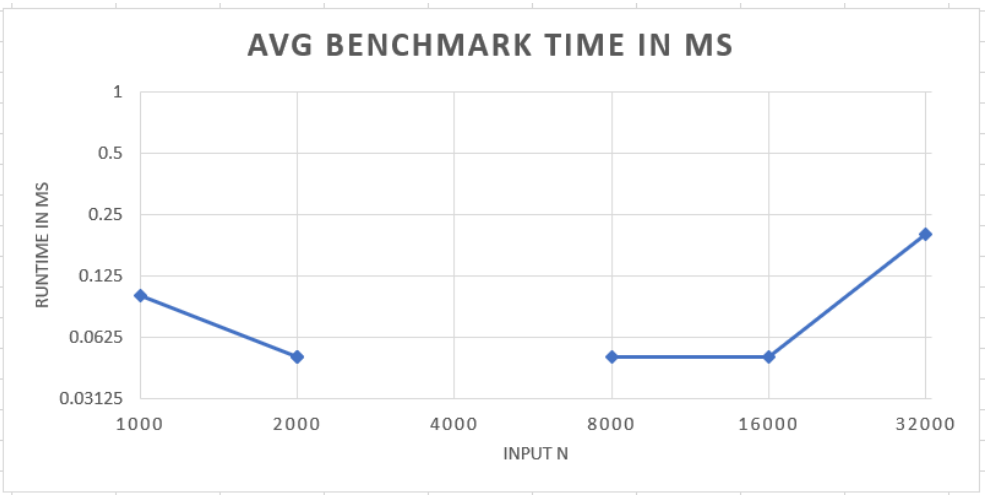
1. After benchmarking for Random Array and Reversed array, I observed that there was similar time taken to sort the array of size N.
2. For Partially Ordered Array, when compared to random and reverse array, it took less time while sorting as the array was partially sorted due to which the insertion sort was not going into the second for loop for the existing sorted portion.
3. Ordered Array took almost no time during the insertion sort.

● Evidence to support conclusion and Graphical Representation:

Below plotted is log log graph of the Benchmark time in ms and the input N.

1. Ordered Array

	A	B
1	**Array Length**	**Avg Benchmark time in ms**
2	1000	0.1
3	2000	0.05
4	4000	0
5	8000	0.05
6	16000	0.05
7	32000	0.2



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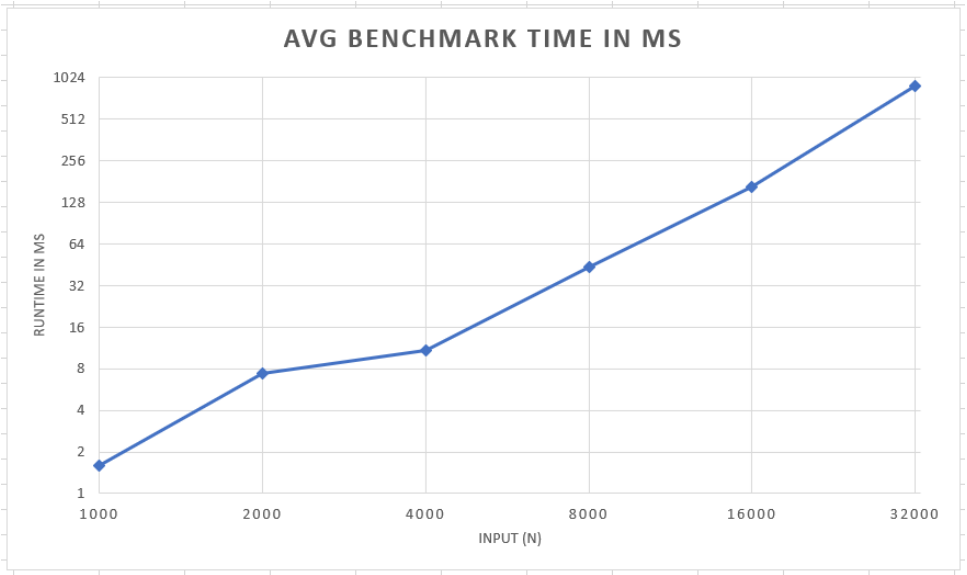
2. Partially Ordered Array

	A	B
1	Array Length	Avg Benchmark time in ms
2	1000	1.6
3	2000	7.4
4	4000	10.9
5	8000	43.6
6	16000	163.05
7	32000	871.35



3. Random Array

	A	B
1	Array Length	Avg Benchmark time in ms
2	1000	2.8
3	2000	9.8
4	4000	41.25
5	8000	136.4
6	16000	393.65
7	32000	2312.45

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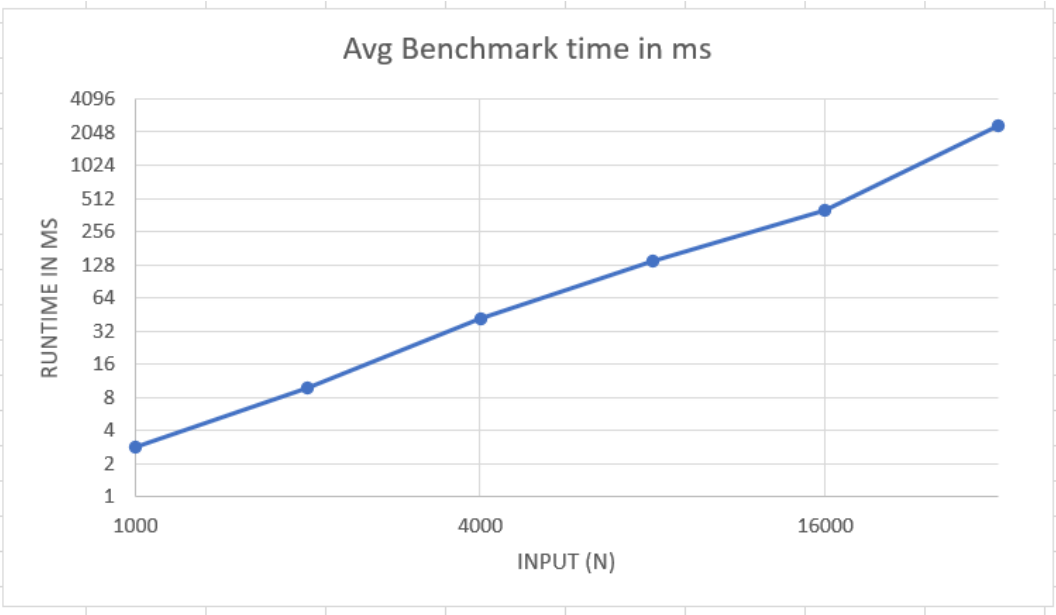
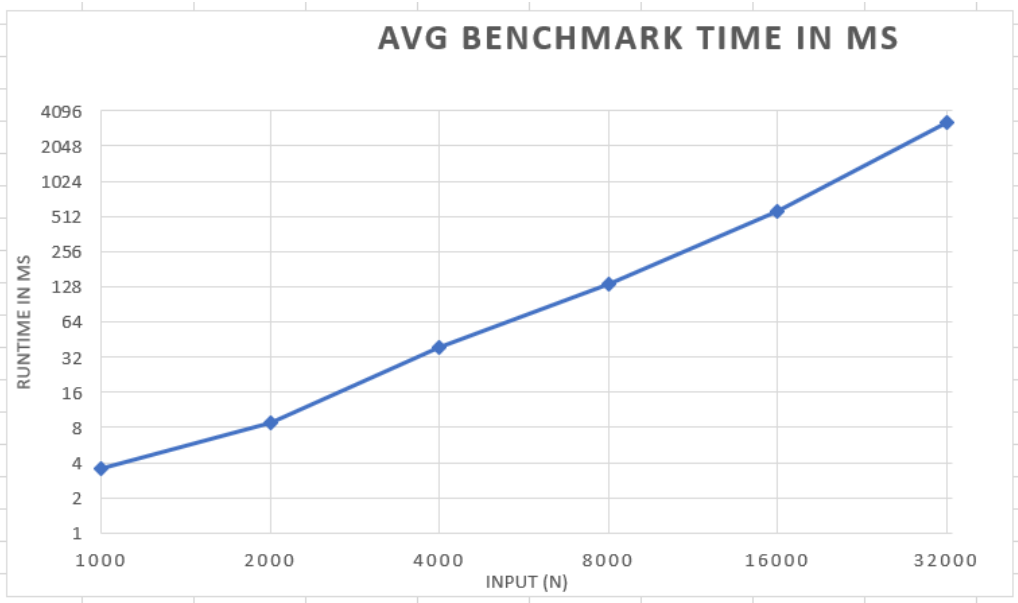


4. Reversed Array

	A	B
1	**Array Length**	**Avg Benchmark time in ms**
2	1000	3.6
3	2000	8.7
4	4000	38.8
5	8000	136.15
6	16000	570.45
7	32000	3276.95



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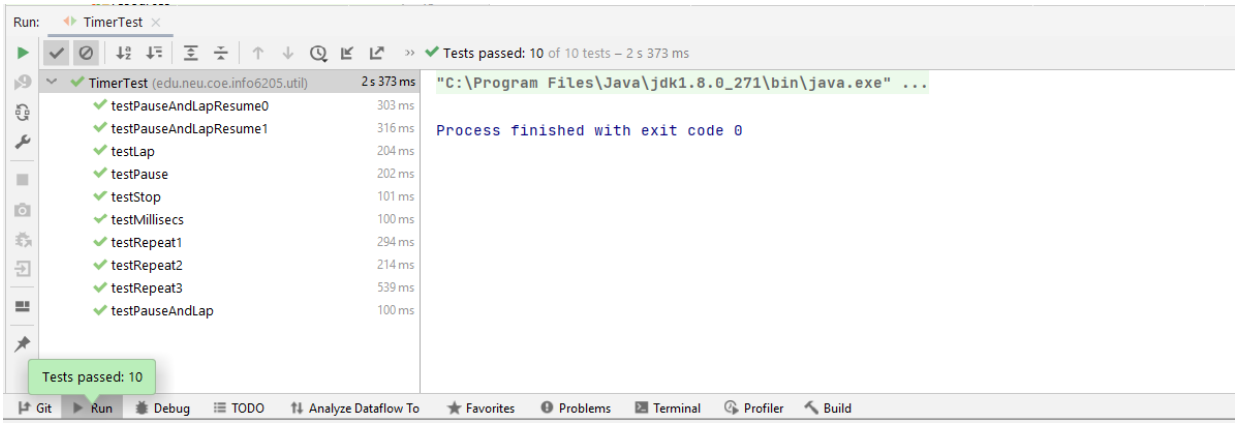
- ## Unit test results:

Passed all test cases in BenchmarkTest, TimerTest and InsertionSortTest**.**

1. BenchmarkTest:

2. TimerTest:



3. InsertionSortTest: