Program Structures and Algorithms
Assignment-3

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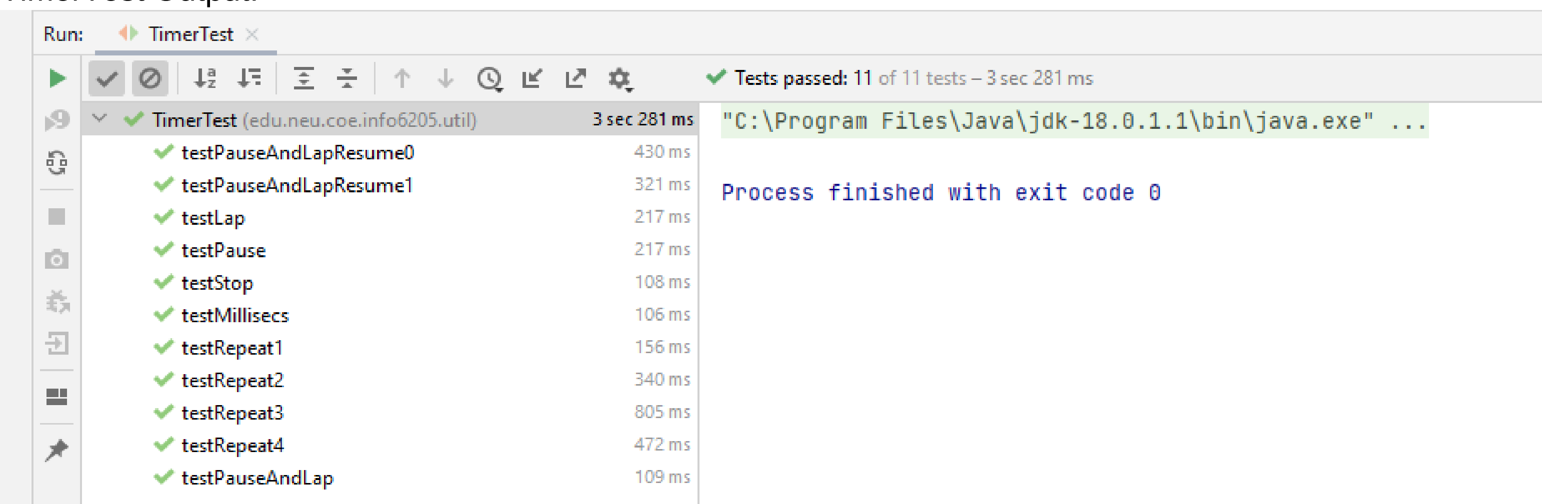
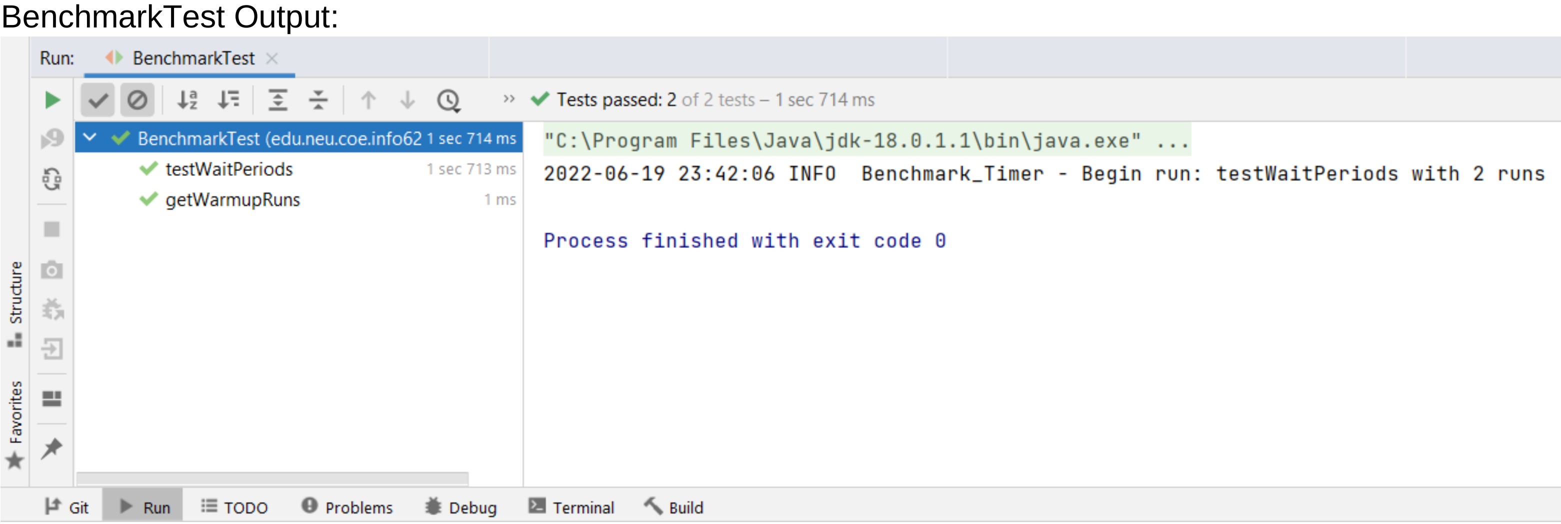
Task-1: You are to implement three (3) methods (repeat, getClock, and toMillisecs) of a class called Timer. Please see the skeleton class that is created in the repository. Timer is invoked from a class called Benchmark_Timer which implements the Benchmark interface. Don't forget to check your implementation by running the unit tests in BenchmarkTest and TimerTest. If you have trouble with the exact timings in the unit tests, it's quite OK (in this assignment only) to change parameters until the tests run. Different machine architectures will result in different behavior.

Output:

TimerTest Output:



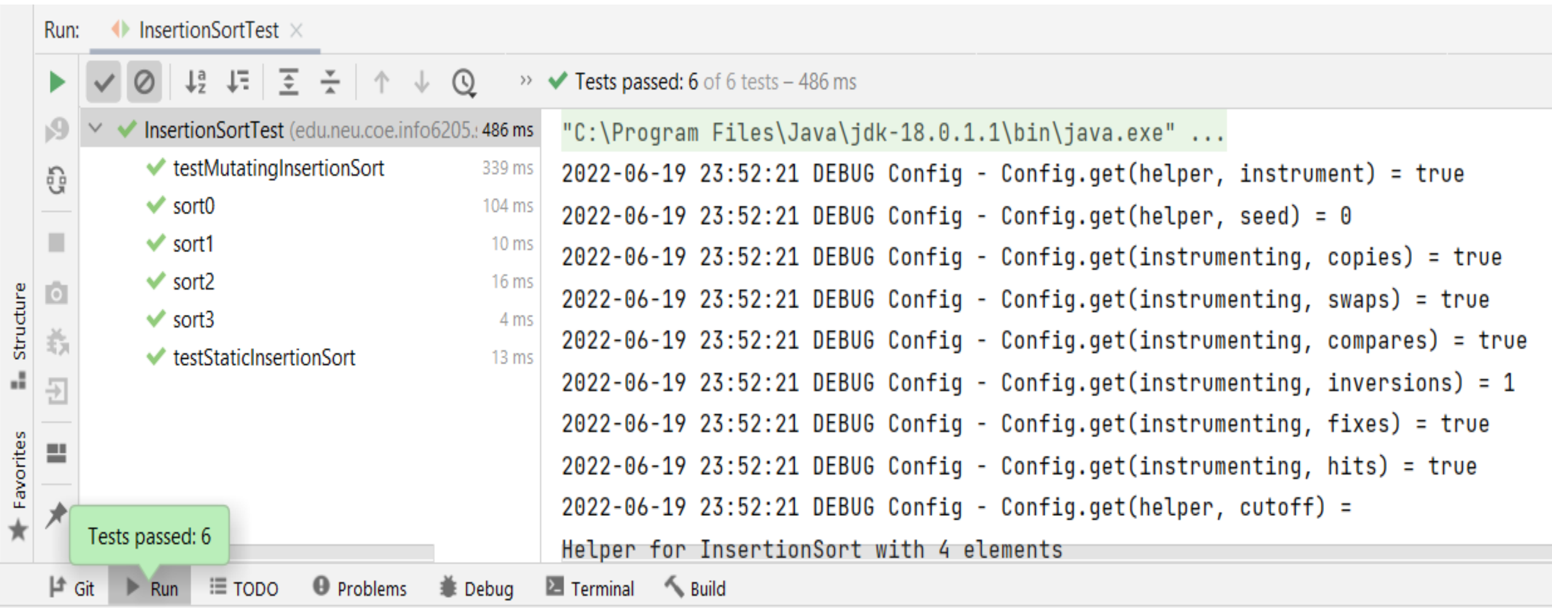
BenchmarkTest Output:



Task-2: Implement *InsertionSort* (in the *InsertionSort* class) by simply looking up the insertion code used by *Arrays.sort.* If you have the *instrument = true* setting in *test/resources/config.ini*, then you will need to use the *helper* methods for comparing and swapping (so that they properly count the number of swaps/compares). The easiest is to use the *helper.swapStableConditional* method, continuing if it returns true, otherwise breaking the loop. Alternatively, if you are not using instrumenting, then you can write (or copy) your own compare/swap code. Either way, you must run the unit tests in *InsertionSortTest*.

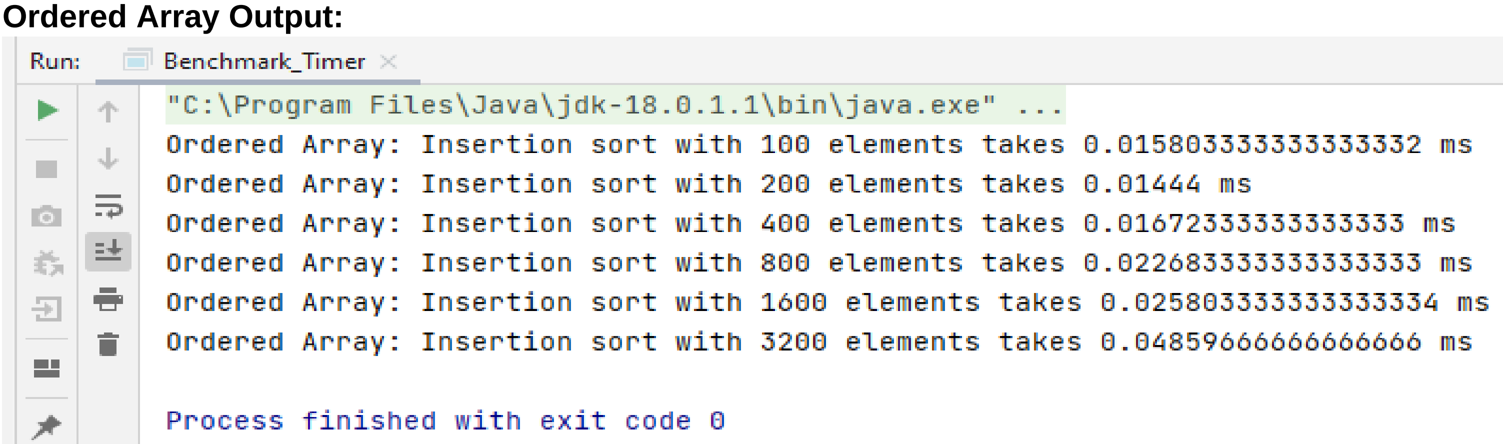
Output:

InsertionSortTest



Task-3: Implement a main program (or you could do it via your own unit tests) to actually 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. I suggest that your arrays to be sorted are of type *Integer*. 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.

Ordered Array Output:



Partially Ordered Array Output:

```
Run:   Benchmark_Timer ×
"C:\Program Files\Java\jdk-18.0.1.1\bin\java.exe" ...
Partailly Ordered Array: Insertion sort with 100 elements takes 0.011843333333333334 ms
Partailly Ordered Array: Insertion sort with 200 elements takes 0.017546666666666665 ms
Partailly Ordered Array: Insertion sort with 400 elements takes 0.026453333333333332 ms
Partailly Ordered Array: Insertion sort with 800 elements takes 0.028296666666666668 ms
Partailly Ordered Array: Insertion sort with 1600 elements takes 0.045603333333333333 ms
Partailly Ordered Array: Insertion sort with 3200 elements takes 0.060129999999999996 ms

Process finished with exit code 0
```

Random Array Output:

```
Run:   Benchmark_Timer ×
"C:\Program Files\Java\jdk-18.0.1.1\bin\java.exe" ...
Random Array: Insertion sort with 100 elements takes 0.01099 ms
Random Array: Insertion sort with 200 elements takes 0.01558 ms
Random Array: Insertion sort with 400 elements takes 0.018 ms
Random Array: Insertion sort with 800 elements takes 0.023719999999999998 ms
Random Array: Insertion sort with 1600 elements takes 0.0494 ms
Random Array: Insertion sort with 3200 elements takes 0.187 ms

Process finished with exit code 0
```

Revese Ordered Array Output:

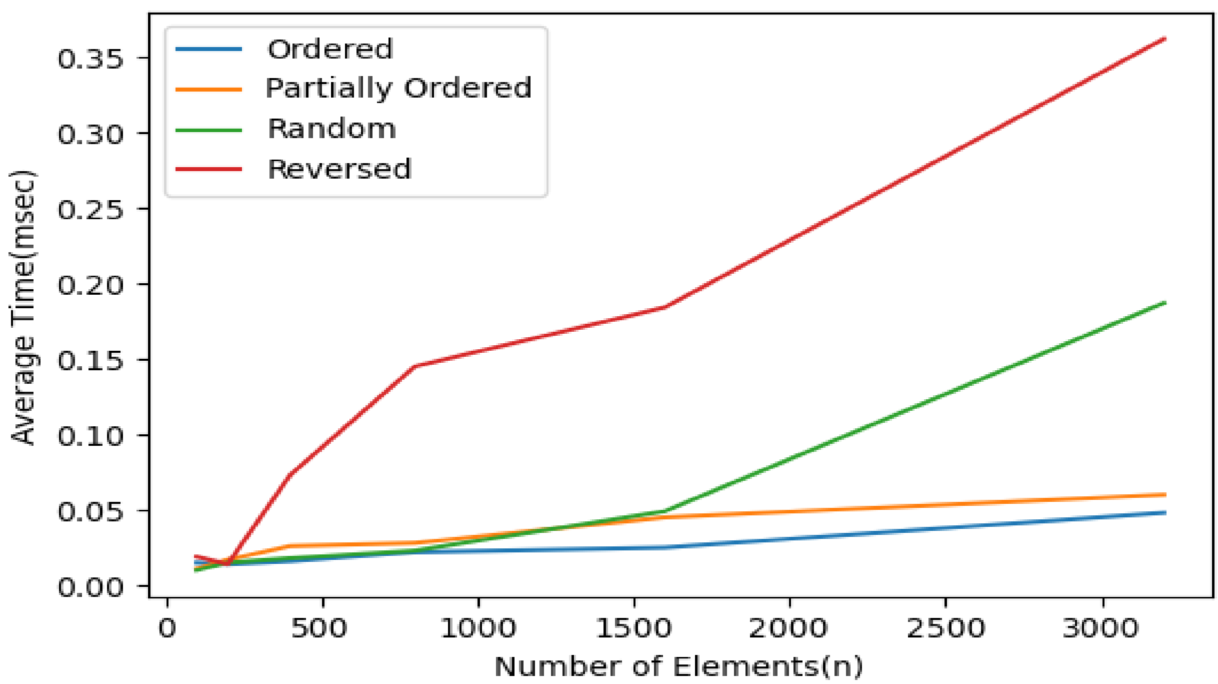
```
Run:   Benchmark_Timer ×
"C:\Program Files\Java\jdk-18.0.1.1\bin\java.exe" ...
Reverse Ordered Array: Insertion sort with 100 elements takes 0.0196 ms
Reverse Ordered Array: Insertion sort with 200 elements takes 0.01489 ms
Reverse Ordered Array: Insertion sort with 400 elements takes 0.0732 ms
Reverse Ordered Array: Insertion sort with 800 elements takes 0.1454 ms
Reverse Ordered Array: Insertion sort with 1600 elements takes 0.18439999999999998 ms
Reverse Ordered Array: Insertion sort with 3200 elements takes 0.3621 ms

Process finished with exit code 0
```

Comparison Table:

N	Ordered Array	Partially Ordered Array	Random Array	Reversed Array
100	0.015	0.011	0.010	0.019
200	0.014	0.017	0.015	0.014
400	0.016	0.026	0.018	0.073
800	0.022	0.028	0.023	0.145
1600	0.025	0.045	0.049	0.184
3200	0.048	0.060	0.187	0.362

Comparison Graph:



Conclusion :

From the above graph and analysis, we observe that the order of time taken by each different arrangement of elements in an array is -

Ordered array < partially ordered array < random array < reversed array