Program Structures & Algorithms

Assignment No. 2 - Benchmark

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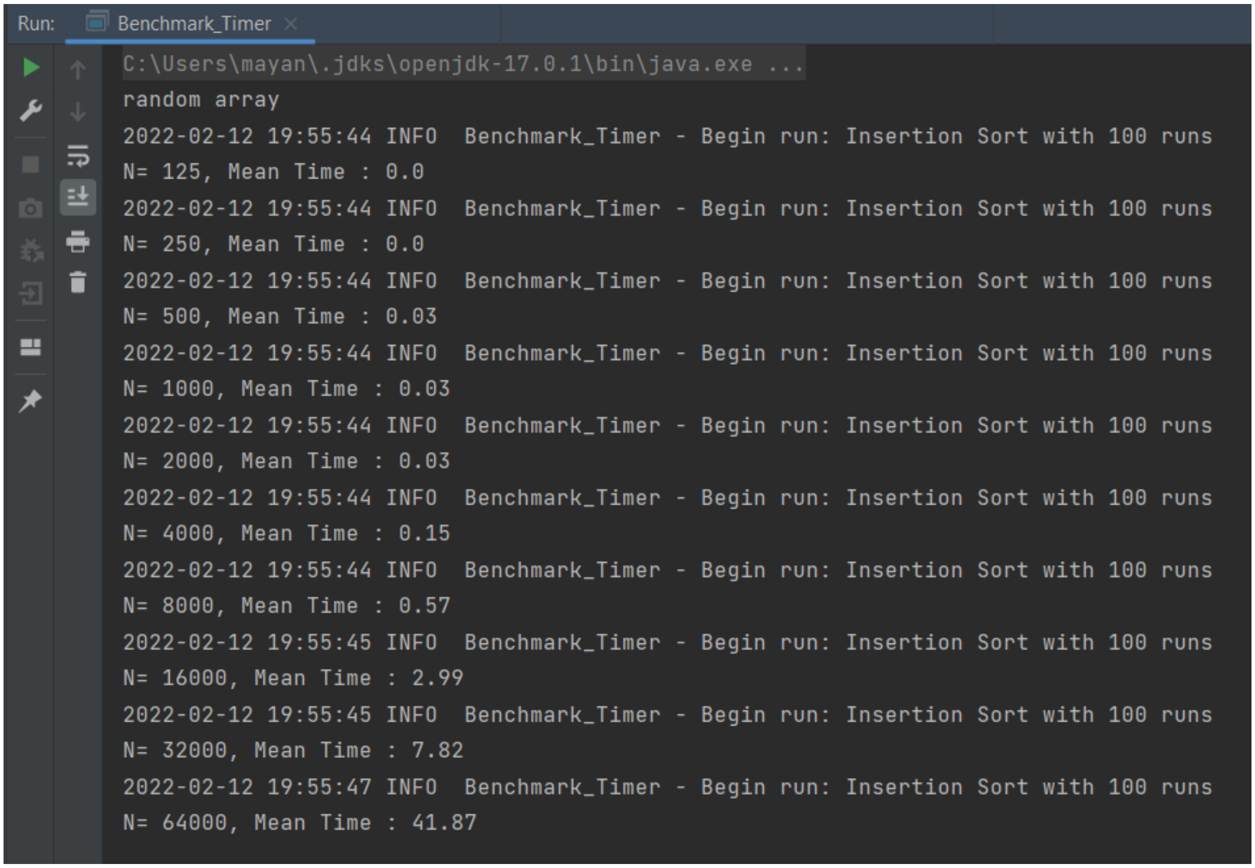
Task:

- (Part 1) You are to implement three (3) methods (*repeat*, *getClock*, and *toMillisecs*) of a class called *Timer*.
- (Part 2) Implement *InsertionSort* (in the *InsertionSort* class) by simply looking up the insertion code used by *Arrays.sort*.
- (Part 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.

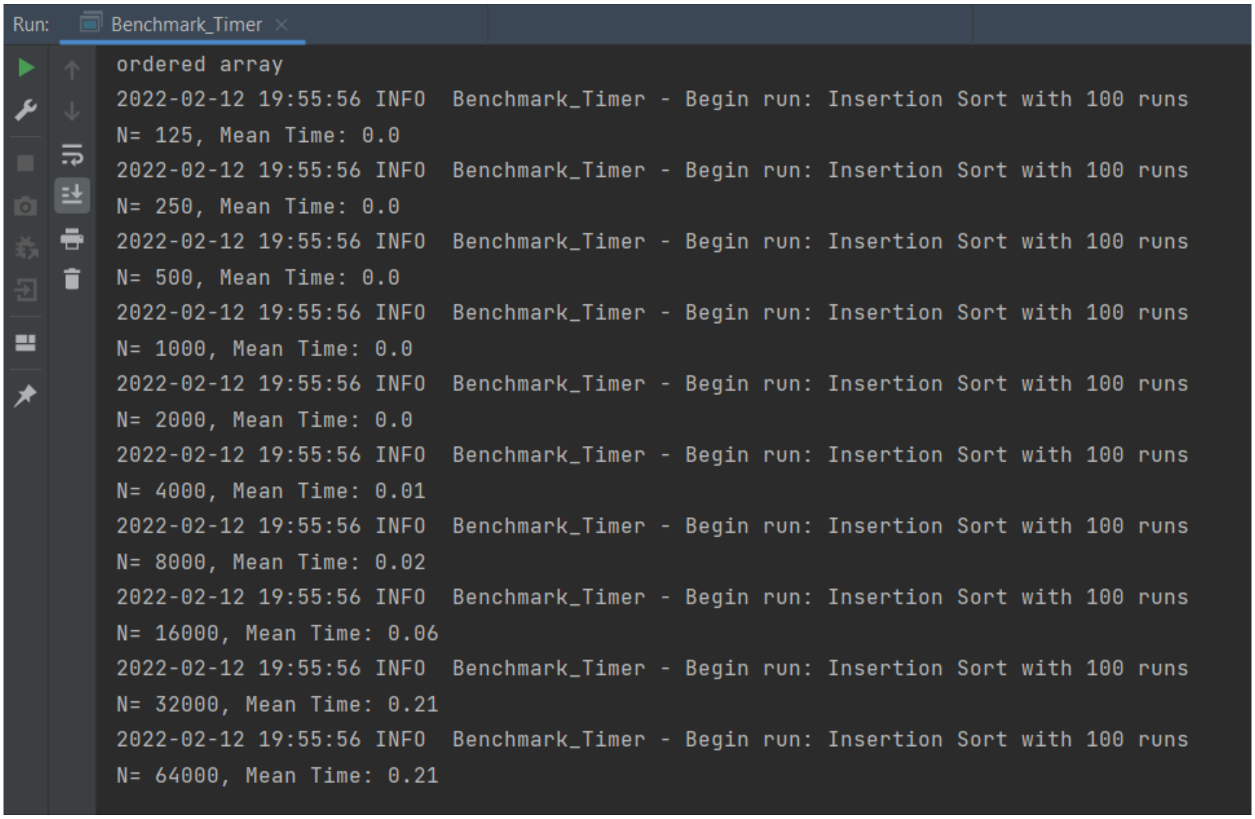
Output Values:

Random Ordered Array-



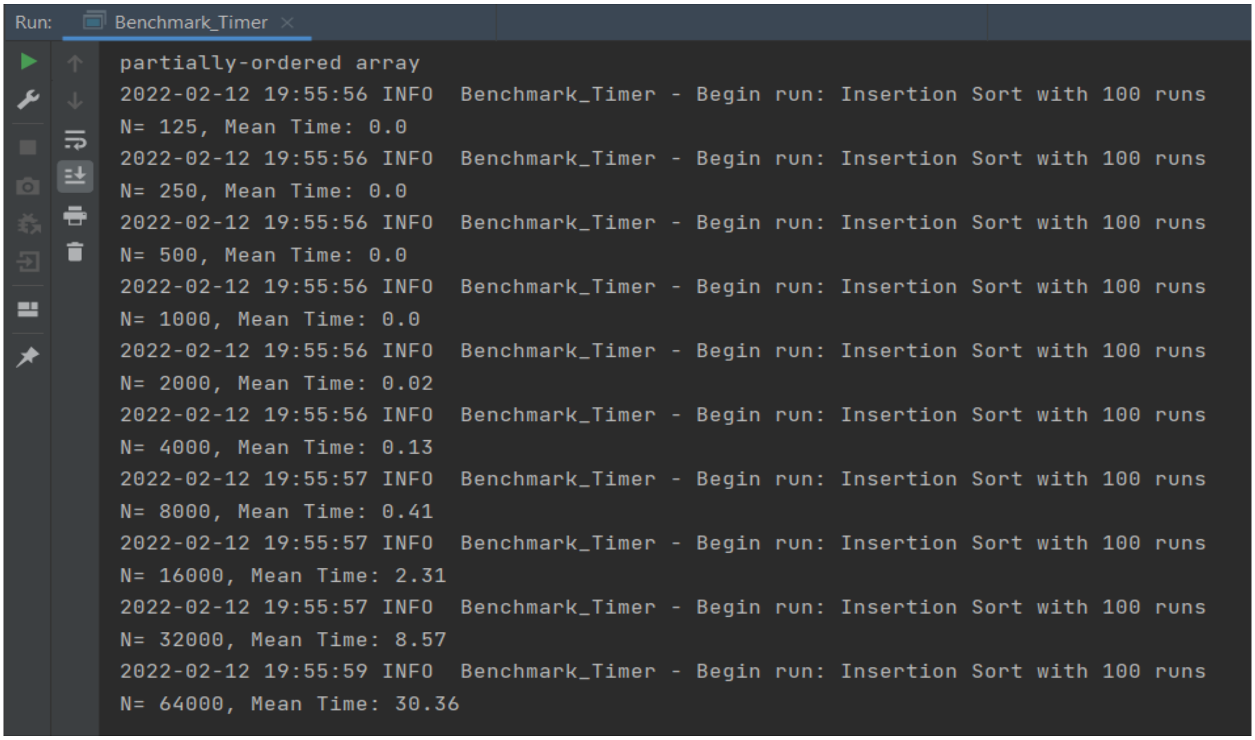
```
C:\Users\mayan\.jdks\openjdk-17.0.1\bin\java.exe ...
random array
2022-02-12 19:55:44 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 125, Mean Time : 0.0
2022-02-12 19:55:44 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 250, Mean Time : 0.0
2022-02-12 19:55:44 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 500, Mean Time : 0.03
2022-02-12 19:55:44 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 1000, Mean Time : 0.03
2022-02-12 19:55:44 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 2000, Mean Time : 0.03
2022-02-12 19:55:44 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 4000, Mean Time : 0.15
2022-02-12 19:55:44 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 8000, Mean Time : 0.57
2022-02-12 19:55:45 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 16000, Mean Time : 2.99
2022-02-12 19:55:45 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 32000, Mean Time : 7.82
2022-02-12 19:55:47 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 64000, Mean Time : 41.87
```

Ordered Array:



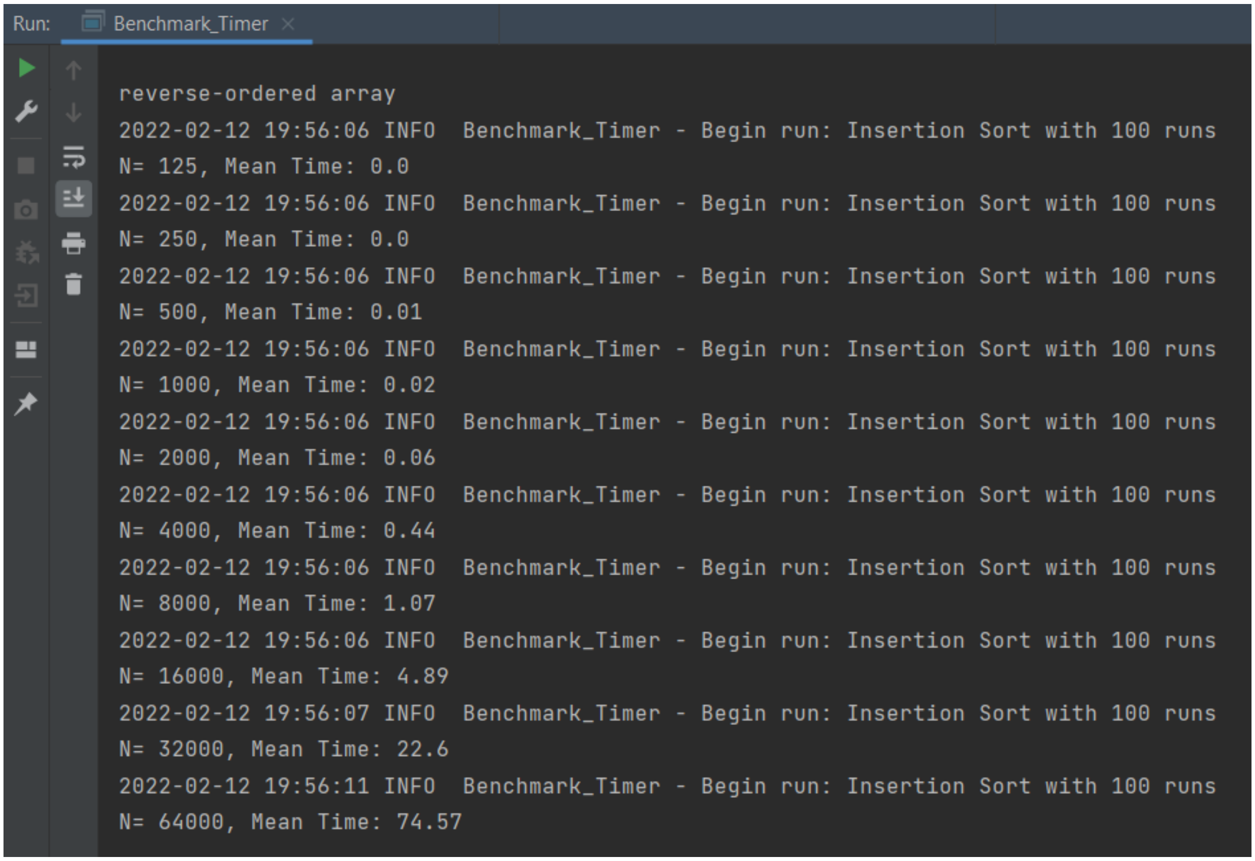
```
ordered array
2022-02-12 19:55:56 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 125, Mean Time: 0.0
2022-02-12 19:55:56 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 250, Mean Time: 0.0
2022-02-12 19:55:56 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 500, Mean Time: 0.0
2022-02-12 19:55:56 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 1000, Mean Time: 0.0
2022-02-12 19:55:56 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 2000, Mean Time: 0.0
2022-02-12 19:55:56 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 4000, Mean Time: 0.01
2022-02-12 19:55:56 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 8000, Mean Time: 0.02
2022-02-12 19:55:56 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 16000, Mean Time: 0.06
2022-02-12 19:55:56 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 32000, Mean Time: 0.21
2022-02-12 19:55:56 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 64000, Mean Time: 0.21
```

Partially Ordered Array:



```
partially-ordered array
2022-02-12 19:55:56 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 125, Mean Time: 0.0
2022-02-12 19:55:56 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 250, Mean Time: 0.0
2022-02-12 19:55:56 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 500, Mean Time: 0.0
2022-02-12 19:55:56 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 1000, Mean Time: 0.0
2022-02-12 19:55:56 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 2000, Mean Time: 0.02
2022-02-12 19:55:56 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 4000, Mean Time: 0.13
2022-02-12 19:55:57 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 8000, Mean Time: 0.41
2022-02-12 19:55:57 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 16000, Mean Time: 2.31
2022-02-12 19:55:57 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 32000, Mean Time: 8.57
2022-02-12 19:55:59 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 64000, Mean Time: 30.36
```

Reverse Ordered Array:



```
reverse-ordered array
2022-02-12 19:56:06 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 125, Mean Time: 0.0
2022-02-12 19:56:06 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 250, Mean Time: 0.0
2022-02-12 19:56:06 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 500, Mean Time: 0.01
2022-02-12 19:56:06 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 1000, Mean Time: 0.02
2022-02-12 19:56:06 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 2000, Mean Time: 0.06
2022-02-12 19:56:06 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 4000, Mean Time: 0.44
2022-02-12 19:56:06 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 8000, Mean Time: 1.07
2022-02-12 19:56:06 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 16000, Mean Time: 4.89
2022-02-12 19:56:07 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 32000, Mean Time: 22.6
2022-02-12 19:56:11 INFO  Benchmark_Timer - Begin run: Insertion Sort with 100 runs
N= 64000, Mean Time: 74.57
```

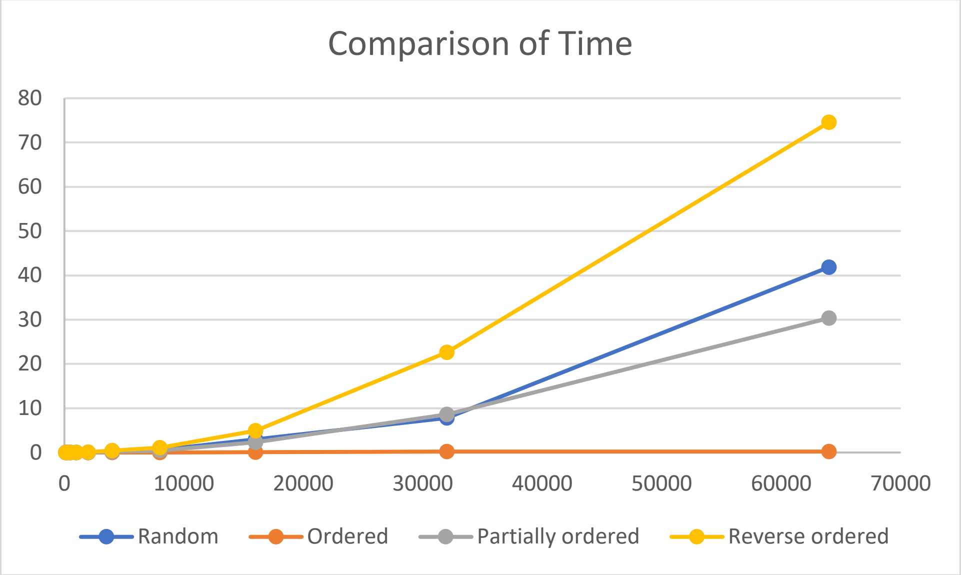
<u>Code:</u>

Benchmark_Timer, Timer, InsertionSort files attached.

Observations:

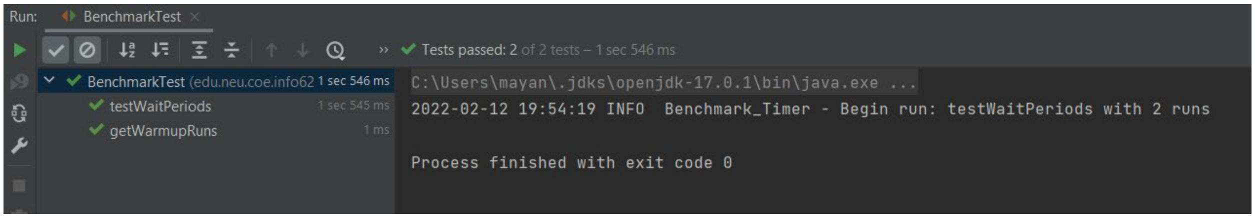
Plotting all the values of N (x-axis) and mean time taken (y-axis), we can clearly see that after performing around 100 runs for each N, ordered array outperforms every other array type and reverse ordered array performs the worst. We can compare their performance in following order

ordered -> partially-ordered -> random -> reverse-ordered



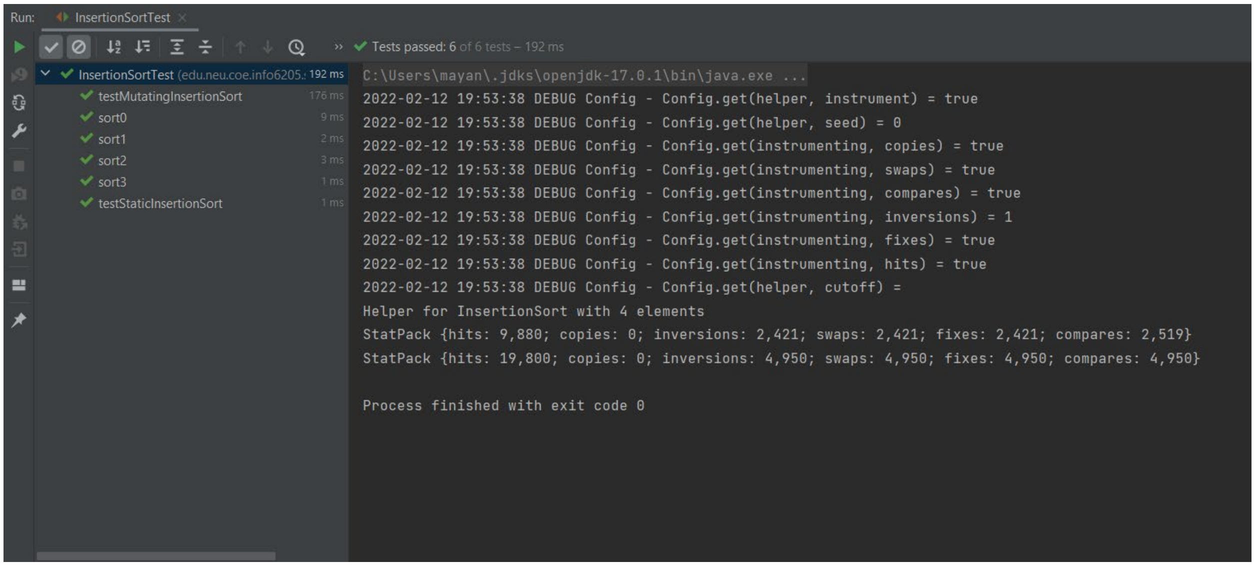
Test Cases:

BenchmartTest:


Run:
BenchmarkTest
Tests passed: 2 of 2 tests – 1 sec 546 ms
BenchmarkTest (edu.neu.coe.info62 1 sec 546 ms
testWaitPeriods 1 sec 545 ms
getWarmupRuns 1 ms

```
C:\Users\mayan\.jdks\openjdk-17.0.1\bin\java.exe ...
2022-02-12 19:54:19 INFO  Benchmark_Timer - Begin run: testWaitPeriods with 2 runs

Process finished with exit code 0
```



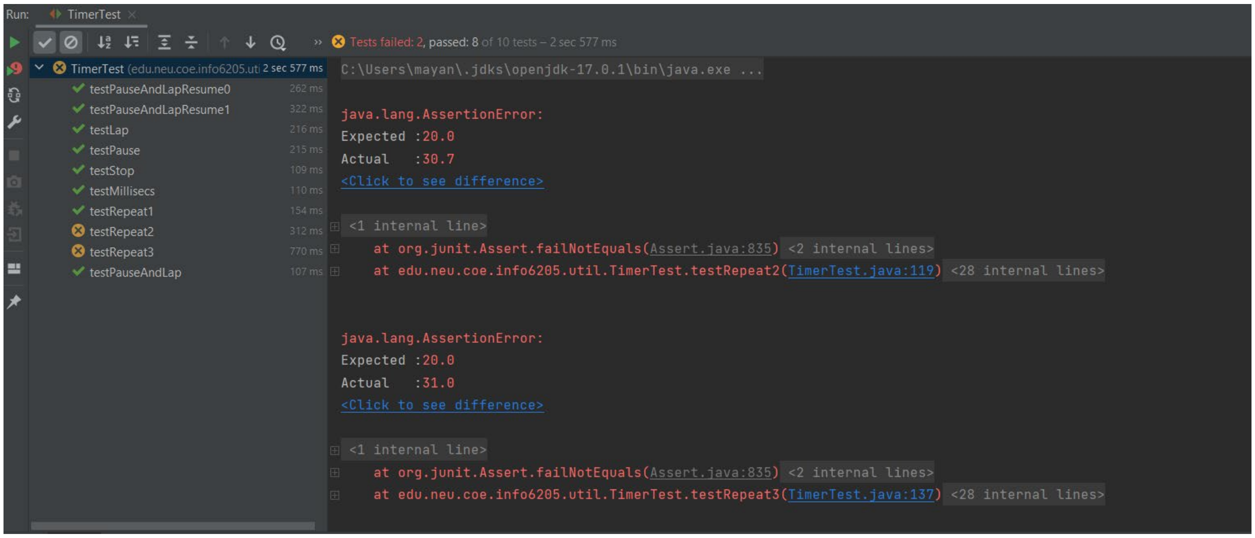
```
Tests passed: 6 of 6 tests – 192 ms

InsertionSortTest (edu.neu.coe.info6205.: 192 ms
    testMutatingInsertionSort   176 ms
    sort0                         9 ms
    sort1                         2 ms
    sort2                         3 ms
    sort3                         1 ms
    testStaticInsertionSort       1 ms
```

```
C:\Users\mayan\.jdks\openjdk-17.0.1\bin\java.exe ...
2022-02-12 19:53:38 DEBUG Config - Config.get(helper, instrument) = true
2022-02-12 19:53:38 DEBUG Config - Config.get(helper, seed) = 0
2022-02-12 19:53:38 DEBUG Config - Config.get(instrumenting, copies) = true
2022-02-12 19:53:38 DEBUG Config - Config.get(instrumenting, swaps) = true
2022-02-12 19:53:38 DEBUG Config - Config.get(instrumenting, compares) = true
2022-02-12 19:53:38 DEBUG Config - Config.get(instrumenting, inversions) = 1
2022-02-12 19:53:38 DEBUG Config - Config.get(instrumenting, fixes) = true
2022-02-12 19:53:38 DEBUG Config - Config.get(instrumenting, hits) = true
2022-02-12 19:53:38 DEBUG Config - Config.get(helper, cutoff) = 
Helper for InsertionSort with 4 elements
StatPack {hits: 9,880; copies: 0; inversions: 2,421; swaps: 2,421; fixes: 2,421; compares: 2,519}
StatPack {hits: 19,800; copies: 0; inversions: 4,950; swaps: 4,950; fixes: 4,950; compares: 4,950}

Process finished with exit code 0
```

TimerTest:



```
Tests failed: 2, passed: 8 of 10 tests – 2 sec 577 ms

TimerTest (edu.neu.coe.info6205.uti 2 sec 577 ms
    testPauseAndLapResume0   262 ms
    testPauseAndLapResume1   322 ms
    testLap                  216 ms
    testPause                215 ms
    testStop                 109 ms
    testMillisecs            110 ms
    testRepeat1              154 ms
    testRepeat2              312 ms
    testRepeat3              770 ms
    testPauseAndLap          107 ms
```

```
C:\Users\mayan\.jdks\openjdk-17.0.1\bin\java.exe ...

java.lang.AssertionError: 
Expected :20.0
Actual   :30.7
<Click to see difference>

<1 internal line>
    at org.junit.Assert.failNotEquals(Assert.java:835) <2 internal lines>
    at edu.neu.coe.info6205.util.TimerTest.testRepeat2(TimerTest.java:119) <28 internal lines>


java.lang.AssertionError: 
Expected :20.0
Actual   :31.0
<Click to see difference>

<1 internal line>
    at org.junit.Assert.failNotEquals(Assert.java:835) <2 internal lines>
    at edu.neu.coe.info6205.util.TimerTest.testRepeat3(TimerTest.java:137) <28 internal lines>
```