

Program Structures & Algorithms

Spring 2022

Assignment No. 2 - Benchmark

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Task

Part 1 Implement the required methods in Timer.java.

1. Updated getClock() method to get the current system's time in nanoseconds.
2. Updated toMilliSecs() method to get milliseconds value from ticks.
3. Updated repeat method to get mean lap time values.

Part 2 Implement the required methods in Timer.java.

Implemented Insertion Sort with the help of Arrays.sort() the helper class.

Part 3 Measure running time

Created a new class in the test directory to check the running time of different types of arrays.

Relationship Conclusion

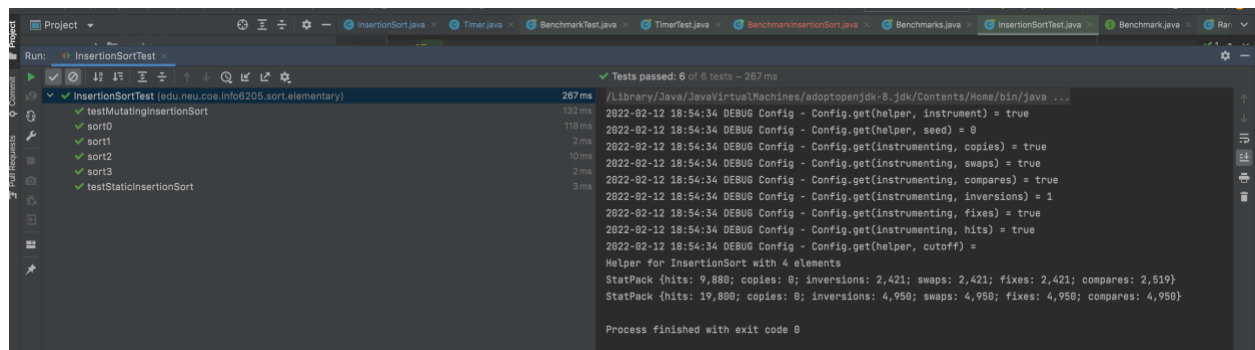
Worst Case time complexity is $O(n^2)$.

Mean Lap Time = $1/N$ *

Reciprocal of N is approximately equal to mean lap time value and holds mostly true.

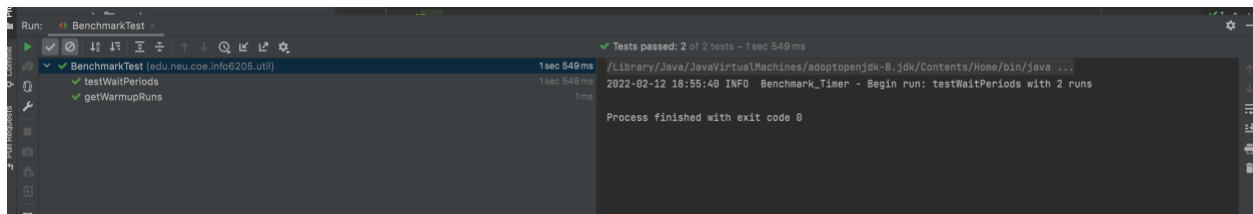
Output screenshot

Insertion Sort Test

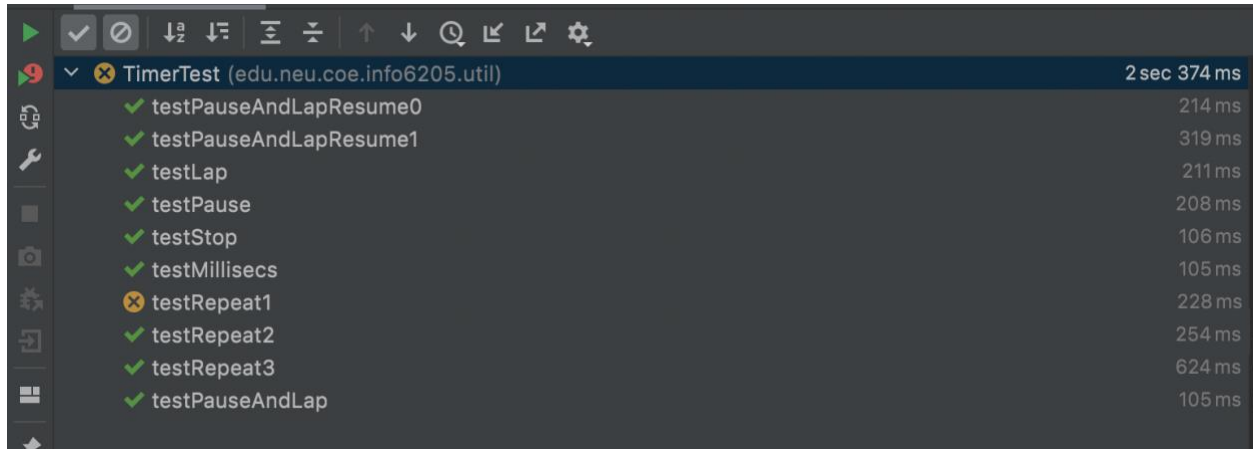


```
Run: InsertionSortTest
Tests passed: 6 of 6 tests - 267 ms
InsertionSortTest (edu.neu.coe.info6205.sort.elementary) 267 ms
  ✓ testMutatingInsertionSort 112 ms
  ✓ sort0 118 ms
  ✓ sort1 2 ms
  ✓ sort2 10 ms
  ✓ sort3 2 ms
  ✓ testStaticInsertionSort 3 ms
/Library/Java/JavaVirtualMachines/adoptopenjdk-8.jdk/Contents/Home/bin/java ...
2022-02-12 18:54:34 DEBUG Config - Config.get(helper, instrument) = true
2022-02-12 18:54:34 DEBUG Config - Config.get(helper, seed) = 0
2022-02-12 18:54:34 DEBUG Config - Config.get(instrumenting, copies) = true
2022-02-12 18:54:34 DEBUG Config - Config.get(instrumenting, swaps) = true
2022-02-12 18:54:34 DEBUG Config - Config.get(instrumenting, compares) = true
2022-02-12 18:54:34 DEBUG Config - Config.get(instrumenting, inversions) = 1
2022-02-12 18:54:34 DEBUG Config - Config.get(instrumenting, fixes) = true
2022-02-12 18:54:34 DEBUG Config - Config.get(instrumenting, hits) = true
2022-02-12 18:54:34 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: 19,880; copies: 0; inversions: 4,950; swaps: 4,950; fixes: 4,950; compares: 4,950}
Process finished with exit code 0
```

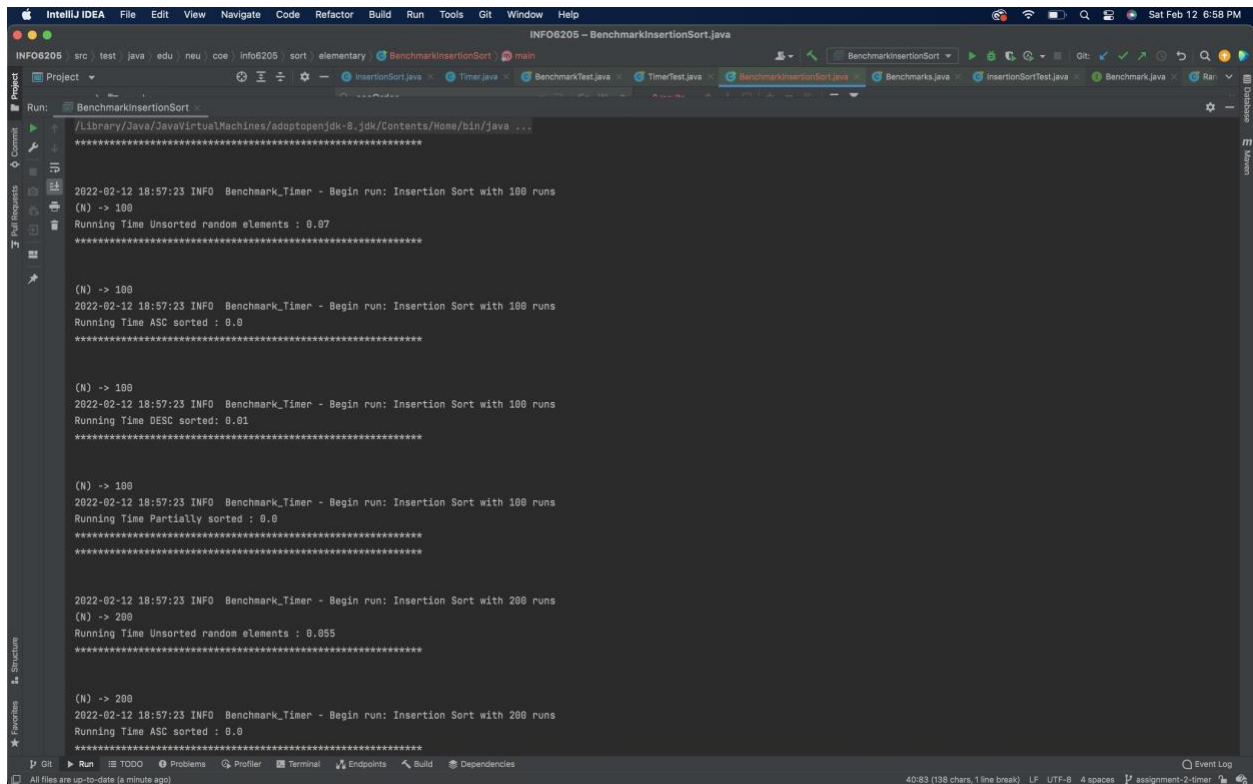
Benchmark Test



Time Test



Benchmark – Insertion Sort Test Output



```
IntelliJ IDEA File Edit View Navigate Code Refactor Build Run Tools Git Window Help
INFO6205 - BenchmarkInsertionSort.java
INFO6205 src test java edu neu coe info6205 sort elementary BenchmarkInsertionSort main
Project Run: BenchmarkInsertionSort
(N) -> 200
2022-02-12 18:57:23 INFO Benchmark_Timer - Begin run: Insertion Sort with 200 runs
Running Time DESC sorted: 0.0
*****

(N) -> 200
2022-02-12 18:57:23 INFO Benchmark_Timer - Begin run: Insertion Sort with 200 runs
Running Time Partially sorted : 0.0
*****

2022-02-12 18:57:23 INFO Benchmark_Timer - Begin run: Insertion Sort with 300 runs
(N) -> 300
Running Time Unsorted random elements : 0.07333333333333333
*****

(N) -> 300
2022-02-12 18:57:23 INFO Benchmark_Timer - Begin run: Insertion Sort with 300 runs
Running Time ASC sorted : 0.0
*****

(N) -> 300
2022-02-12 18:57:23 INFO Benchmark_Timer - Begin run: Insertion Sort with 300 runs
Running Time DESC sorted: 0.0033333333333333335
*****

(N) -> 300
2022-02-12 18:57:23 INFO Benchmark_Timer - Begin run: Insertion Sort with 300 runs
Running Time Partially sorted : 0.0
*****

2022-02-12 18:57:23 INFO Benchmark_Timer - Begin run: Insertion Sort with 400 runs
(N) -> 400
Running Time Unsorted random elements : 0.135
*****

(N) -> 400
2022-02-12 18:57:23 INFO Benchmark_Timer - Begin run: Insertion Sort with 400 runs
Running Time ASC sorted : 0.0
*****

(N) -> 400
2022-02-12 18:57:23 INFO Benchmark_Timer - Begin run: Insertion Sort with 400 runs
Running Time DESC sorted: 0.0
*****

(N) -> 400
2022-02-12 18:57:23 INFO Benchmark_Timer - Begin run: Insertion Sort with 400 runs
Running Time Partially sorted : 0.0025
*****

2022-02-12 18:57:23 INFO Benchmark_Timer - Begin run: Insertion Sort with 500 runs
(N) -> 500
Running Time Unsorted random elements : 0.202
*****

(N) -> 500
2022-02-12 18:57:23 INFO Benchmark_Timer - Begin run: Insertion Sort with 500 runs
Running Time ASC sorted : 0.002
*****

(N) -> 500
2022-02-12 18:57:23 INFO Benchmark_Timer - Begin run: Insertion Sort with 500 runs
Running Time DESC sorted: 0.002
*****

(N) -> 500
2022-02-12 18:57:23 INFO Benchmark_Timer - Begin run: Insertion Sort with 500 runs
Running Time Partially sorted : 0.002
*****

Git Run TODO Problems Profiler Terminal Endpoints Build Dependencies
All files are up-to-date (a minute ago)
40/83 (138 chars, 1 line break) LF UTF-8 4 spaces assignment-2-timer 40%
```

```
IntelliJ IDEA File Edit View Navigate Code Refactor Build Run Tools Git Window Help
INFO6205 - BenchmarkInsertionSort.java
INFO6205 src test java edu neu coe info6205 sort elementary BenchmarkInsertionSort main
Project Run: BenchmarkInsertionSort
2022-02-12 18:57:23 INFO Benchmark_Timer - Begin run: Insertion Sort with 400 runs
(N) -> 400
Running Time Unsorted random elements : 0.135
*****

(N) -> 400
2022-02-12 18:57:23 INFO Benchmark_Timer - Begin run: Insertion Sort with 400 runs
Running Time ASC sorted : 0.0
*****

(N) -> 400
2022-02-12 18:57:23 INFO Benchmark_Timer - Begin run: Insertion Sort with 400 runs
Running Time DESC sorted: 0.0
*****

(N) -> 400
2022-02-12 18:57:23 INFO Benchmark_Timer - Begin run: Insertion Sort with 400 runs
Running Time Partially sorted : 0.0025
*****

2022-02-12 18:57:23 INFO Benchmark_Timer - Begin run: Insertion Sort with 500 runs
(N) -> 500
Running Time Unsorted random elements : 0.202
*****

(N) -> 500
2022-02-12 18:57:23 INFO Benchmark_Timer - Begin run: Insertion Sort with 500 runs
Running Time ASC sorted : 0.002
*****

(N) -> 500
2022-02-12 18:57:23 INFO Benchmark_Timer - Begin run: Insertion Sort with 500 runs
Running Time DESC sorted: 0.002
*****

(N) -> 500
2022-02-12 18:57:23 INFO Benchmark_Timer - Begin run: Insertion Sort with 500 runs
Running Time Partially sorted : 0.002
*****

Git Run TODO Problems Profiler Terminal Endpoints Build Dependencies
All files are up-to-date (a minute ago)
40/83 (138 chars, 1 line break) LF UTF-8 4 spaces assignment-2-timer 40%
```

```
IntelliJ IDEA File Edit View Navigate Code Refactor Build Run Tools Git Window Help
INFO6205 - BenchmarkInsertionSort.java
INFO6205 src test java edu neu coe info6205 sort elementary BenchmarkInsertionSort main
Project Run: BenchmarkInsertionSort
(N) -> 500
2022-02-12 18:57:23 INFO Benchmark_Timer - Begin run: Insertion Sort with 500 runs
Running Time DESC sorted: 0.004
*****

(N) -> 500
2022-02-12 18:57:23 INFO Benchmark_Timer - Begin run: Insertion Sort with 500 runs
Running Time Partially sorted : 0.004
*****

2022-02-12 18:57:23 INFO Benchmark_Timer - Begin run: Insertion Sort with 600 runs
(N) -> 600
Running Time Unsorted random elements : 0.23833333333333334
*****

(N) -> 600
2022-02-12 18:57:23 INFO Benchmark_Timer - Begin run: Insertion Sort with 600 runs
Running Time ASC sorted : 0.0033333333333333335
*****

(N) -> 600
2022-02-12 18:57:23 INFO Benchmark_Timer - Begin run: Insertion Sort with 600 runs
Running Time DESC sorted: 0.0033333333333333335
*****

(N) -> 600
2022-02-12 18:57:23 INFO Benchmark_Timer - Begin run: Insertion Sort with 600 runs
Running Time Partially sorted : 0.005
*****

Run: BenchmarkInsertionSort
40/83 (138 chars, 1 line break) LF UTF-8 4 spaces assignment-2-timer
```

```
IntelliJ IDEA File Edit View Navigate Code Refactor Build Run Tools Git Window Help
INFO6205 - BenchmarkInsertionSort.java
INFO6205 src test java edu neu coe info6205 sort elementary BenchmarkInsertionSort main
Project Run: BenchmarkInsertionSort
2022-02-12 18:57:23 INFO Benchmark_Timer - Begin run: Insertion Sort with 700 runs
(N) -> 700
Running Time Unsorted random elements : 0.5814285714285714
*****

(N) -> 700
2022-02-12 18:57:23 INFO Benchmark_Timer - Begin run: Insertion Sort with 700 runs
Running Time ASC sorted : 0.004285714285714286
*****

(N) -> 700
2022-02-12 18:57:23 INFO Benchmark_Timer - Begin run: Insertion Sort with 700 runs
Running Time DESC sorted: 0.004285714285714286
*****

(N) -> 700
2022-02-12 18:57:23 INFO Benchmark_Timer - Begin run: Insertion Sort with 700 runs
Running Time Partially sorted : 0.024285714285714285
*****

2022-02-12 18:57:23 INFO Benchmark_Timer - Begin run: Insertion Sort with 800 runs
(N) -> 800
Running Time Unsorted random elements : 0.7375
*****

(N) -> 800
2022-02-12 18:57:24 INFO Benchmark_Timer - Begin run: Insertion Sort with 800 runs
Running Time ASC sorted : 0.00375
*****

(N) -> 800
*****

Run: BenchmarkInsertionSort
40/83 (138 chars, 1 line break) LF UTF-8 4 spaces assignment-2-timer
```

```
IntelliJ IDEA File Edit View Navigate Code Refactor Build Run Tools Git Window Help
INFO6205 - BenchmarkInsertionSort.java
INFO6205 src test java edu neu coe info6205 sort elementary BenchmarkInsertionSort main
Project
Run: BenchmarkInsertionSort
(N) -> 800
2022-02-12 18:57:24 INFO Benchmark_Timer - Begin run: Insertion Sort with 800 runs
Running Time DESC sorted: 0.00375
*****

(N) -> 800
2022-02-12 18:57:24 INFO Benchmark_Timer - Begin run: Insertion Sort with 800 runs
Running Time Partially sorted : 0.00375
*****

2022-02-12 18:57:24 INFO Benchmark_Timer - Begin run: Insertion Sort with 900 runs
(N) -> 900
Running Time Unsorted random elements : 0.8844444444444445
*****

(N) -> 900
2022-02-12 18:57:25 INFO Benchmark_Timer - Begin run: Insertion Sort with 900 runs
Running Time ASC sorted : 0.004444444444444444
*****

(N) -> 900
2022-02-12 18:57:25 INFO Benchmark_Timer - Begin run: Insertion Sort with 900 runs
Running Time DESC sorted: 0.004444444444444444
*****

(N) -> 900
2022-02-12 18:57:25 INFO Benchmark_Timer - Begin run: Insertion Sort with 900 runs
Running Time Partially sorted : 0.004444444444444444
*****

*****

*****
40/83 (138 chars, 1 line break) LF UTF-8 4 spaces assignment-2-timer
```

```
IntelliJ IDEA File Edit View Navigate Code Refactor Build Run Tools Git Window Help
INFO6205 - BenchmarkInsertionSort.java
INFO6205 src test java edu neu coe info6205 sort elementary BenchmarkInsertionSort main
Project
Run: BenchmarkInsertionSort
(N) -> 900
2022-02-12 18:57:25 INFO Benchmark_Timer - Begin run: Insertion Sort with 900 runs
Running Time DESC sorted: 0.004444444444444444
*****

(N) -> 900
2022-02-12 18:57:25 INFO Benchmark_Timer - Begin run: Insertion Sort with 900 runs
Running Time Partially sorted : 0.004444444444444444
*****

2022-02-12 18:57:25 INFO Benchmark_Timer - Begin run: Insertion Sort with 1,000 runs
(N) -> 1000
Running Time Unsorted random elements : 1.042
*****

(N) -> 1000
2022-02-12 18:57:26 INFO Benchmark_Timer - Begin run: Insertion Sort with 1,000 runs
Running Time ASC sorted : 0.005
*****

(N) -> 1000
2022-02-12 18:57:26 INFO Benchmark_Timer - Begin run: Insertion Sort with 1,000 runs
Running Time DESC sorted: 0.008
*****

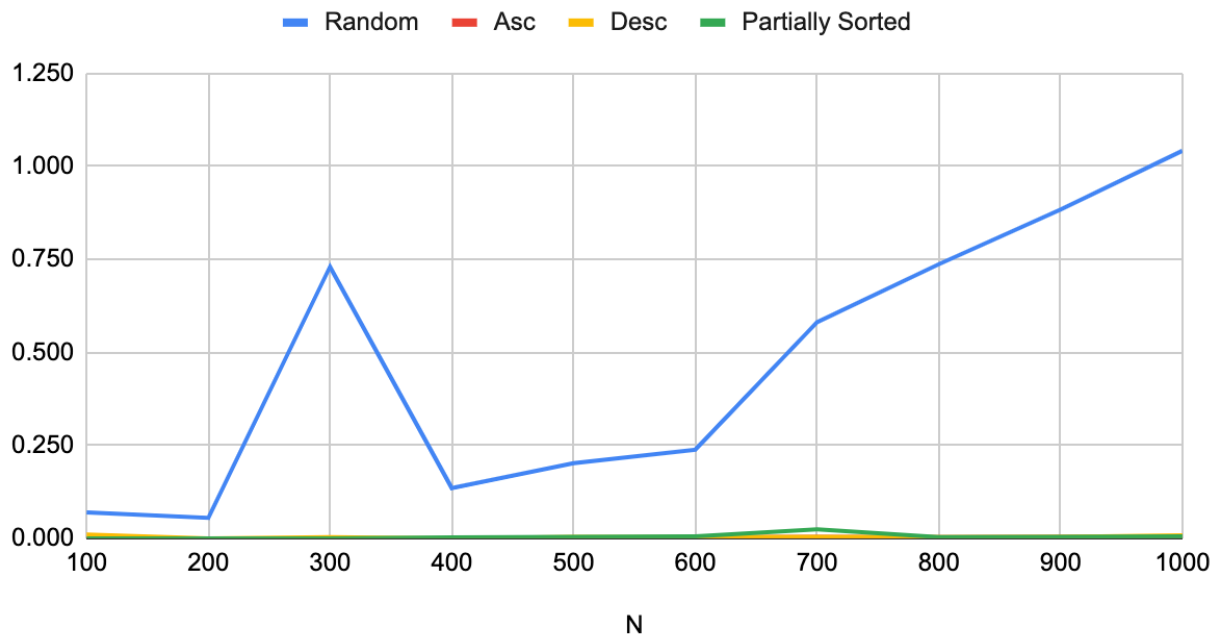
(N) -> 1000
2022-02-12 18:57:26 INFO Benchmark_Timer - Begin run: Insertion Sort with 1,000 runs
Running Time Partially sorted : 0.005
*****

*****

Process finished with exit code 0
40/83 (138 chars, 1 line break) LF UTF-8 4 spaces assignment-2-timer
```

- Evidence / Graph

RT1, RT2, RT3 and RT4



- Code

```
package edu.neu.coe.info6205.sort.elementary;

import edu.neu.coe.info6205.sort.BaseHelper;
import edu.neu.coe.info6205.sort.Helper;
import edu.neu.coe.info6205.util.ConfigTest;
import edu.neu.coe.info6205.sort.SortWithHelper;
import edu.neu.coe.info6205.util.Benchmark;
import edu.neu.coe.info6205.util.Benchmark_Timer;

import java.io.IOException;

public class BenchmarkInsertionSort {

    public static void main(String[] args) throws IOException {

        int N = 200;

        for (int i = 0; i <= 5; i++) {
            while (N <= 1600) {
                Helper<Integer> helper = new BaseHelper<>("Insertion
sort", N,
                    ConfigTest.setupConfig("true", "0", "1", "", ""));
                SortWithHelper<Integer> arrSorter = new
InsertionSort<>(helper);
```

```

        Benchmark<Integer[]> benchmarkTimer = new
Benchmark_Timer<Integer[]>("Insertion Sort",
        b -> arrSorter.sort(b));
        Integer[] randomArr = helper.random(Integer.class, r ->
r.nextInt(1000));

System.out.println("*****");

        System.out.println("\n");

        double rndmRunningTime = benchmarkTimer.run(randomArr, N);
System.out.println("(N) -> " + randomArr.length);
System.out.println("Running Time Unsorted random elements
: " + rndmRunningTime);

System.out.println("*****");

        System.out.println("\n");
System.out.println("(N) -> " + randomArr.length);
Integer[] ascArr = arrSorter.sort(randomArr);
double ascRunningTime = benchmarkTimer.run(ascArr, N);
System.out.println("Running Time ASC sorted : " +
ascRunningTime);

System.out.println("*****");

        System.out.println("\n");
arrSorter.sort(ascArr, ascArr.length - 1, 0);
System.out.println("(N) -> " + ascArr.length);
double descRunningOTime = benchmarkTimer.run(ascArr, N);
System.out.println("Running Time DESC sorted: " +
descRunningOTime);

System.out.println("*****");

        System.out.println("\n");
arrSorter.sort(ascArr, 0, (ascArr.length) / 3);
System.out.println("(N) -> " + ascArr.length);
double partialRunningTime = benchmarkTimer.run(ascArr, N);
System.out.println("Running Time Partially sorted : " +
partialRunningTime);

System.out.println("*****");

        N = N + 00;
    }
}

}

}

```