

# Program Structures and Algorithms

## Spring 2023(SEC – 08)

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### Task:

#### 1. Task 1

(Part 1) You are to implement three (3) methods (repeat, getClock, and toMillisecs) of a class called Timer.

Unit Test Screenshots:

The screenshot shows an IDE with the TimerTest.java file open. The file contains two test methods: testPauseAndLapResume0 and testPauseAndLapResume1. The test results window shows that all tests passed, with a total of 11 tests passed in 2 seconds and 564 milliseconds.

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INFO6205 - TimerTest.java
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```

### 3. Task 3:

(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.

#### Relationship Conclusion:

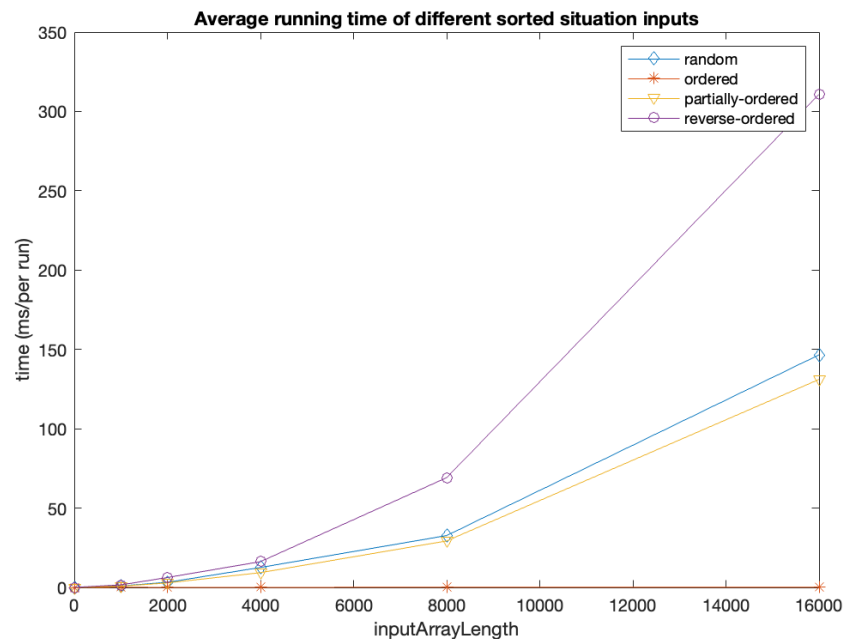
As shown in the average running time of different sorted situation input figuration, the reverse-ordered situation costs the most time, while the costed time of random input is more than the costed time of partially-ordered, and the ordered costs the smallest time.

$$t(\text{reverse} - \text{ordered}) > t(\text{random}) > t(\text{partially} - \text{ordered}) > t(\text{ordered})$$

Besides, with the length of input array increasing, the differences between different situation are becoming larger, since the time complexity of insertion sort algorithm is  $O(n^2)$ .

#### Evidence to support that conclusion:

##### 1. Graphical Representation:



##### 2. The run-time data:

InsertionSort: N = 1000

2023-02-04 16:07:19 INFO Benchmark\_Timer - Begin run: InsertionSortBenchmark with 1,000 runs  
random array inputted, the average time per run is: 0.933ms

2023-02-04 16:07:20 INFO Benchmark\_Timer - Begin run: InsertionSortBenchmark with 1,000 runs  
ordered array inputted, the average time per run is: 0.088ms

2023-02-04 16:07:21 INFO Benchmark\_Timer - Begin run: InsertionSortBenchmark with 1,000 runs  
partially-ordered array inputted, the average time per run is: 0.762ms

2023-02-04 16:07:22 INFO Benchmark\_Timer - Begin run: InsertionSortBenchmark with 1,000 runs

reverse-ordered array inputted, the average time per run is: 1.603ms

-----  
InsertionSort: N = 2000

2023-02-04 16:07:23 INFO Benchmark\_Timer - Begin run: InsertionSortBenchmark with 1,000 runs  
random array inputted, the average time per run is: 3.214ms

2023-02-04 16:07:27 INFO Benchmark\_Timer - Begin run: InsertionSortBenchmark with 1,000 runs  
ordered array inputted, the average time per run is: 0.053ms

2023-02-04 16:07:27 INFO Benchmark\_Timer - Begin run: InsertionSortBenchmark with 1,000 runs  
partially-ordered array inputted, the average time per run is: 2.828ms

2023-02-04 16:07:30 INFO Benchmark\_Timer - Begin run: InsertionSortBenchmark with 1,000 runs  
reverse-ordered array inputted, the average time per run is: 6.237ms

-----  
InsertionSort: N = 4000

2023-02-04 16:07:36 INFO Benchmark\_Timer - Begin run: InsertionSortBenchmark with 1,000 runs  
random array inputted, the average time per run is: 12.575ms

2023-02-04 16:07:49 INFO Benchmark\_Timer - Begin run: InsertionSortBenchmark with 1,000 runs  
ordered array inputted, the average time per run is: 0.059ms

2023-02-04 16:07:50 INFO Benchmark\_Timer - Begin run: InsertionSortBenchmark with 1,000 runs  
partially-ordered array inputted, the average time per run is: 9.306ms

2023-02-04 16:07:59 INFO Benchmark\_Timer - Begin run: InsertionSortBenchmark with 1,000 runs  
reverse-ordered array inputted, the average time per run is: 16.242ms

-----  
InsertionSort: N = 8000

2023-02-04 16:08:16 INFO Benchmark\_Timer - Begin run: InsertionSortBenchmark with 1,000 runs  
random array inputted, the average time per run is: 32.681ms

2023-02-04 16:08:49 INFO Benchmark\_Timer - Begin run: InsertionSortBenchmark with 1,000 runs  
ordered array inputted, the average time per run is: 0.081ms

2023-02-04 16:08:50 INFO Benchmark\_Timer - Begin run: InsertionSortBenchmark with 1,000 runs  
partially-ordered array inputted, the average time per run is: 29.297ms

2023-02-04 16:09:20 INFO Benchmark\_Timer - Begin run: InsertionSortBenchmark with 1,000 runs  
reverse-ordered array inputted, the average time per run is: 69.168ms

-----  
InsertionSort: N = 16000

2023-02-04 16:10:31 INFO Benchmark\_Timer - Begin run: InsertionSortBenchmark with 1,000 runs  
random array inputted, the average time per run is: 146.592ms

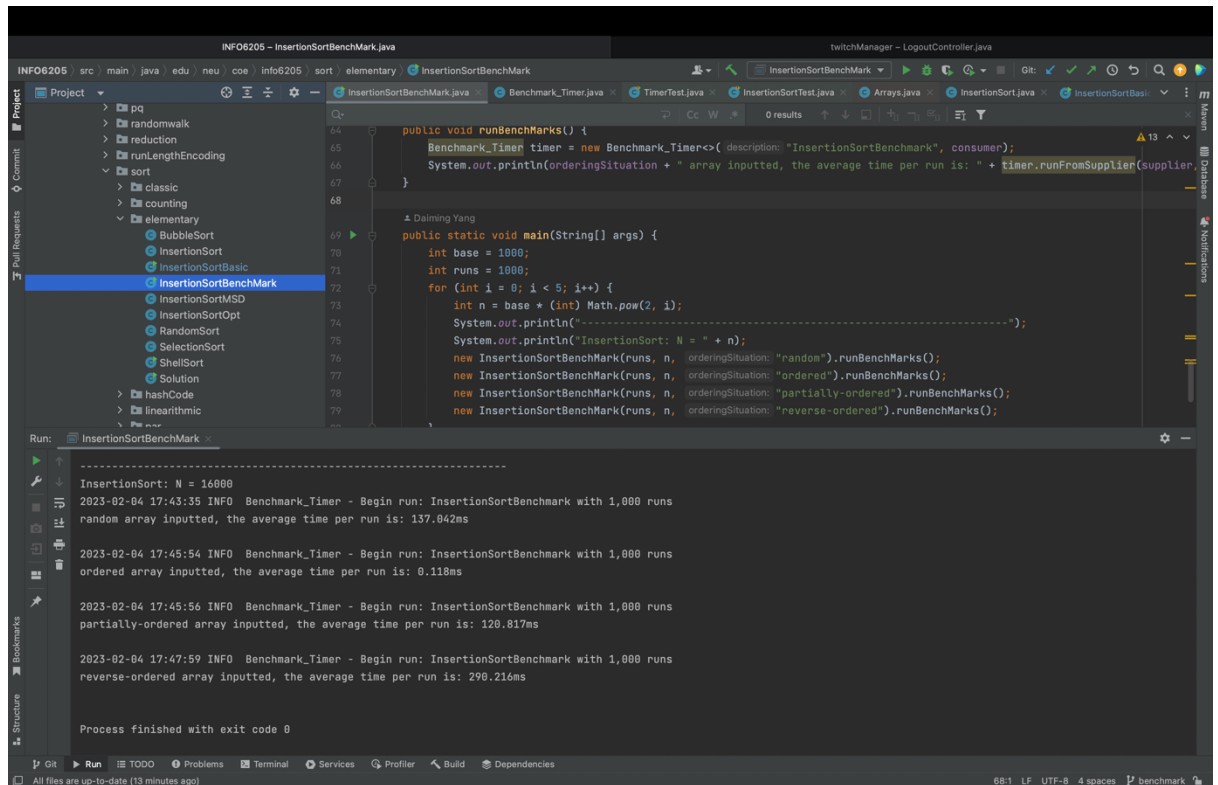
2023-02-04 16:13:00 INFO Benchmark\_Timer - Begin run: InsertionSortBenchmark with 1,000 runs  
ordered array inputted, the average time per run is: 0.094ms

2023-02-04 16:13:02 INFO Benchmark\_Timer - Begin run: InsertionSortBenchmark with 1,000 runs partially-ordered array inputted, the average time per run is: 131.085ms

2023-02-04 16:15:15 INFO Benchmark\_Timer - Begin run: InsertionSortBenchmark with 1,000 runs reverse-ordered array inputted, the average time per run is: 310.77ms

Process finished with exit code 0

Unit Test Screenshots:



The screenshot displays an IDE window for a project named 'INFO6205'. The file 'InsertionSortBenchmark.java' is open, showing a `runBenchMarks()` method and a `main` method. The `main` method initializes a base of 1000 and runs 1000 iterations for different array sizes (16000, 12000, 8000, 4000) and ordering situations (random, ordered, partially-ordered, reverse-ordered). The Run console at the bottom shows the output of the program, including the array size and the average time per run for each configuration.

```
public void runBenchMarks() {
    Benchmark_Timer timer = new Benchmark_Timer<>("InsertionSortBenchmark", consumer);
    System.out.println(orderingSituation + " array inputted, the average time per run is: " + timer.runFromSupplier(supplier));
}

public static void main(String[] args) {
    int base = 1000;
    int runs = 1000;
    for (int i = 0; i < 5; i++) {
        int n = base * (int) Math.pow(2, i);
        System.out.println("-----");
        System.out.println("InsertionSort: N = " + n);
        new InsertionSortBenchmark(runs, n, orderingSituation: "random").runBenchMarks();
        new InsertionSortBenchmark(runs, n, orderingSituation: "ordered").runBenchMarks();
        new InsertionSortBenchmark(runs, n, orderingSituation: "partially-ordered").runBenchMarks();
        new InsertionSortBenchmark(runs, n, orderingSituation: "reverse-ordered").runBenchMarks();
    }
}
```

Run: InsertionSortBenchmark

```
InsertionSort: N = 16000
2023-02-04 17:43:35 INFO Benchmark_Timer - Begin run: InsertionSortBenchmark with 1,000 runs
random array inputted, the average time per run is: 137.042ms

2023-02-04 17:45:54 INFO Benchmark_Timer - Begin run: InsertionSortBenchmark with 1,000 runs
ordered array inputted, the average time per run is: 0.118ms

2023-02-04 17:45:56 INFO Benchmark_Timer - Begin run: InsertionSortBenchmark with 1,000 runs
partially-ordered array inputted, the average time per run is: 120.817ms

2023-02-04 17:47:59 INFO Benchmark_Timer - Begin run: InsertionSortBenchmark with 1,000 runs
reverse-ordered array inputted, the average time per run is: 290.216ms

Process finished with exit code 0
```