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Program Structures & Algorithms
Summer 2021
Assignment No. 2

Task 1

You are to implement three methods of a class called *Timer*. Please see the skeleton class that I created in the repository. *Timer* is invoked from a class called *Benchmark_Timer* which implements the *Benchmark* interface. check your implementation by running the unit tests in *BenchmarkTest* and *TimerTest*.

Output

TimerTest

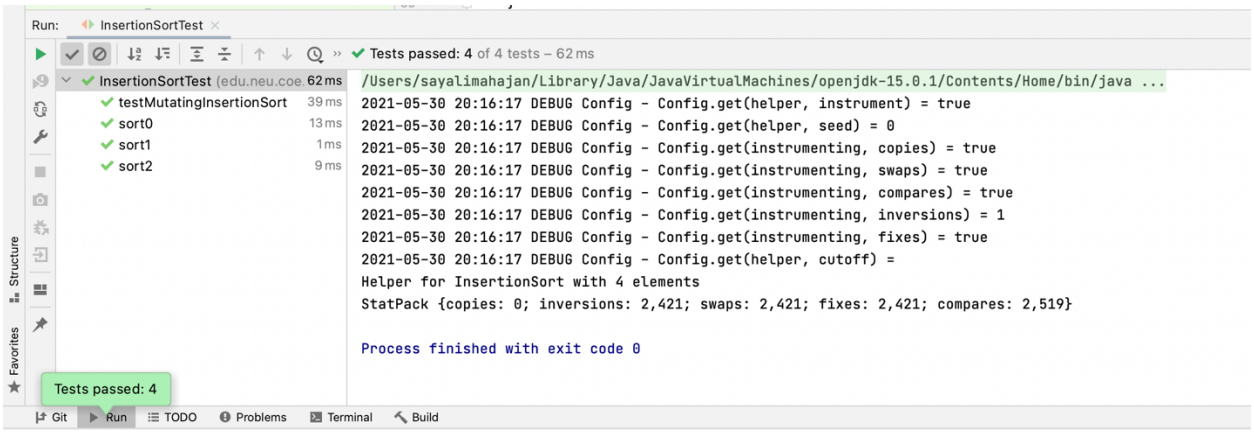
BenchmarkTest

Task 2

Implement *InsertionSort* (in the *InsertionSort* class) by simply looking up the insertion code used by *Arrays.sort.* You should use the *helper.swap* method although you could also just copy that from the same source code. You should of course 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.

Output

Benchmark

```
Run: Benchmark
/Users/sayalimahajan/Library/Java/JavaVirtualMachines/openjdk-15.0.1/Contents/Home/bin/java -java
Random Array: Insertion sort with 100 elements takes 0.22706659999999998 ms
Random Array: Insertion sort with 200 elements takes 0.5344417 ms
Random Array: Insertion sort with 400 elements takes 0.7419041 ms
Random Array: Insertion sort with 800 elements takes 0.9913000000000001 ms
Random Array: Insertion sort with 1600 elements takes 1.9643124999999997 ms
Random Array: Insertion sort with 3200 elements takes 9.5354917 ms
--------------------------------------------------------------------------------
Ordered Array: Insertion sort with 100 elements takes 0.0023875 ms
Ordered Array: Insertion sort with 200 elements takes 0.0027041 ms
Ordered Array: Insertion sort with 400 elements takes 0.005599999999999999 ms
Ordered Array: Insertion sort with 800 elements takes 0.010404199999999999 ms
Ordered Array: Insertion sort with 1600 elements takes 0.0122541 ms
Ordered Array: Insertion sort with 3200 elements takes 0.0384417 ms
--------------------------------------------------------------------------------
Partially Ordered Array: Insertion sort with 100 elements takes 0.0074624999999999995 ms
Partially Ordered Array: Insertion sort with 200 elements takes 0.0317917 ms
Partially Ordered Array: Insertion sort with 400 elements takes 0.1050667 ms
Partially Ordered Array: Insertion sort with 800 elements takes 0.24921249999999998 ms
Partially Ordered Array: Insertion sort with 1600 elements takes 0.8761790999999999 ms
Partially Ordered Array: Insertion sort with 3200 elements takes 3.7572666999999997 ms
--------------------------------------------------------------------------------
Reverse Ordered Array: Insertion sort with 100 elements takes 0.024462499999999998 ms
Reverse Ordered Array: Insertion sort with 200 elements takes 0.11029169999999999 ms
Reverse Ordered Array: Insertion sort with 400 elements takes 0.27981659999999997 ms
Reverse Ordered Array: Insertion sort with 800 elements takes 1.0049959 ms
Reverse Ordered Array: Insertion sort with 1600 elements takes 3.9245125 ms
Reverse Ordered Array: Insertion sort with 3200 elements takes 15.4468334 ms
--------------------------------------------------------------------------------

Process finished with exit code 0
```

Evidence to support the conclusion

No. of Elements in Array(n)						
Array ordering	**100**	**200**	**400**	**800**	**1600**	**3200**
Random	0.2270666	0.5344417	0.7419041	0.9913000	1.9643125	9.5354917
Ordered	0.0023875	0.0027041	0.0055910	0.0104042	0.0122541	0.0384417
Partially ordered	0.0074625	0.0317917	0.1050667	0.2492125	0.8761791	3.7572667
Reversed	0.0244625	0.1102917	0.2798166	1.0049959	3.9245125	15.446833

Graphical Representation

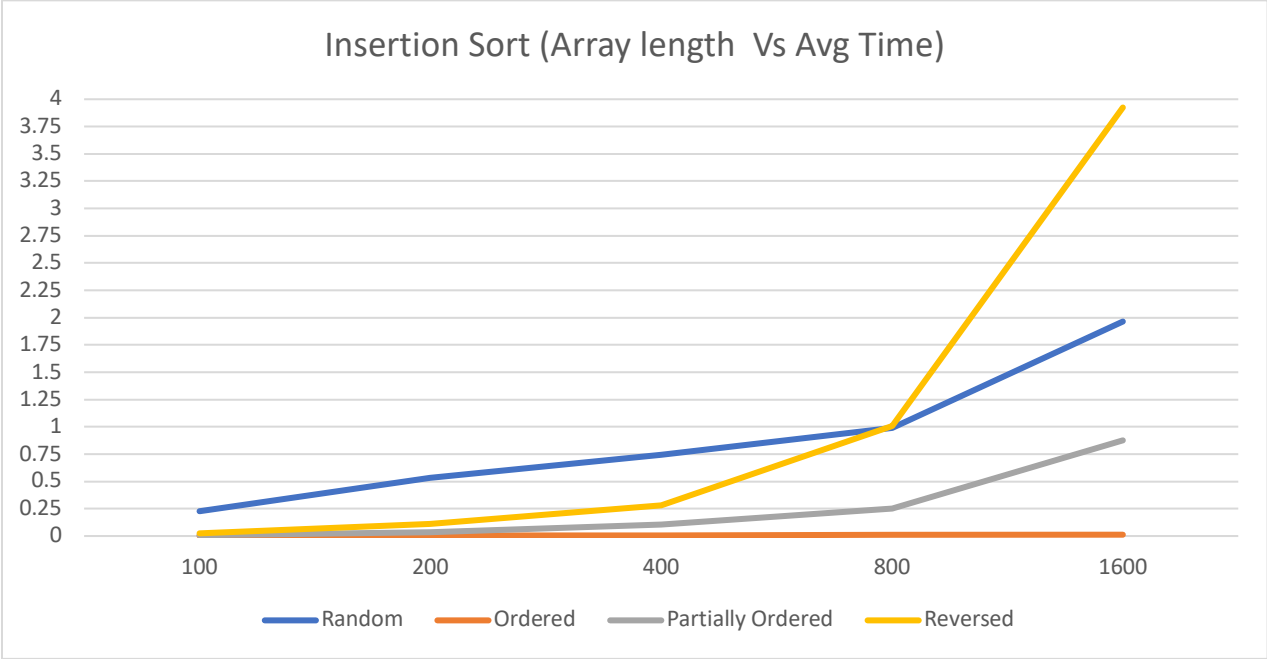


Figure 1 : X represents number of elements in Array whereas Y represents Avg time taken to sort the array

Conclusion

1. Ordered array took minimum time (almost no time) to sort the array using insertion sort among all of types of arrays.
2. In partially ordered array, when you double the size of the array, Time taken to sort the array becomes triple.

3. Reversed array took maximum time to sort the array using insertion sort among all of types of arrays.