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Program Structures & Algorithms
Fall 2021
Assignment NO. 2

- Tasks:
  - Implemented three methods (repeat, getClock, toMillisecs) of the class Timer and passed TimerTest and BenchmarkTest
  - Implemented InsertionSort with helper and passed InsertionSortTest
  - Created a class InsertionSortBenchmark and measured the running time of insertion sort with random, ordered, partially-ordered, reverse-ordered arrays.

- Conclusion:
  - If we double the size of the array, the running time would be approximately the square of the original running time -> quadratic
  - However, if the array is ordered, the running time would be approximately tow times of the original running time, because we only need to do n comparisons -> linear
  - The big O notation for insertion sort is $O(n^2)$
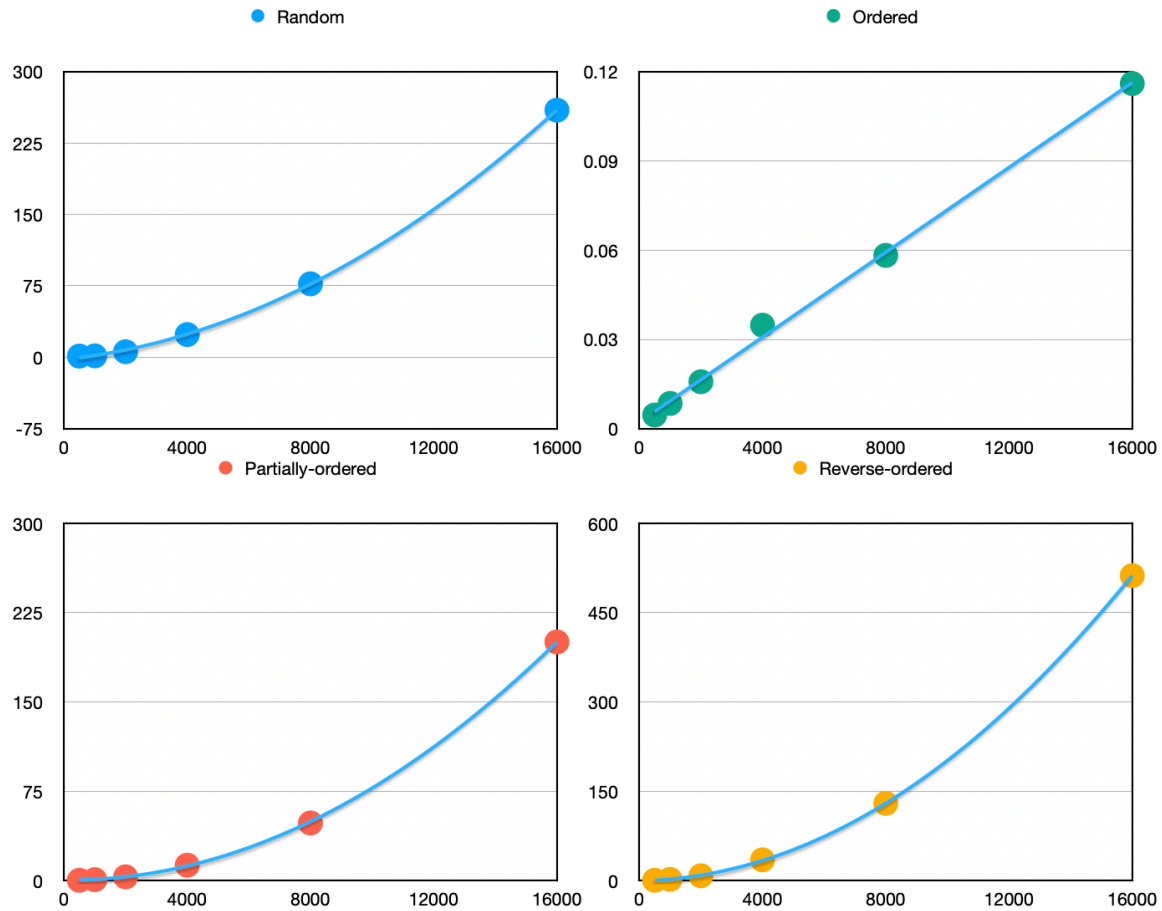
- Evidence to Support the Conclusion:

```
============== Sort random arrays ==============
Size: 500
2021-09-26 18:57:41 INFO  Benchmark_Timer - Begin run: Insertion sort: ordered with 10 runs
1.243178
Size: 1000
2021-09-26 18:57:41 INFO  Benchmark_Timer - Begin run: Insertion sort: ordered with 10 runs
1.4672772
Size: 2000
2021-09-26 18:57:41 INFO  Benchmark_Timer - Begin run: Insertion sort: ordered with 10 runs
5.8056143
Size: 4000
2021-09-26 18:57:41 INFO  Benchmark_Timer - Begin run: Insertion sort: ordered with 10 runs
23.865399099999998
Size: 8000
2021-09-26 18:57:41 INFO  Benchmark_Timer - Begin run: Insertion sort: ordered with 10 runs
77.1327676
Size: 16000
2021-09-26 18:57:43 INFO  Benchmark_Timer - Begin run: Insertion sort: ordered with 10 runs
259.4787478
```

```
============== Sort ordered arrays ==============
Size: 500
2021-09-26 19:05:28 INFO  Benchmark_Timer - Begin run: Insertion sort: ordered with 10 runs
0.0045949
Size: 1000
2021-09-26 19:05:28 INFO  Benchmark_Timer - Begin run: Insertion sort: ordered with 10 runs
0.0084913
Size: 2000
2021-09-26 19:05:28 INFO  Benchmark_Timer - Begin run: Insertion sort: ordered with 10 runs
0.0157823
Size: 4000
2021-09-26 19:05:28 INFO  Benchmark_Timer - Begin run: Insertion sort: ordered with 10 runs
0.0347912
Size: 8000
2021-09-26 19:05:28 INFO  Benchmark_Timer - Begin run: Insertion sort: ordered with 10 runs
0.058229600000000006
Size: 16000
2021-09-26 19:05:28 INFO  Benchmark_Timer - Begin run: Insertion sort: ordered with 10 runs
0.11597740000000001
```

```
============== Sort partially-ordered arrays ==============
Size: 500
2021-09-26 18:57:46 INFO  Benchmark_Timer - Begin run: Insertion sort: ordered with 10 runs
0.2507414
Size: 1000
2021-09-26 18:57:46 INFO  Benchmark_Timer - Begin run: Insertion sort: ordered with 10 runs
0.7731105
Size: 2000
2021-09-26 18:57:46 INFO  Benchmark_Timer - Begin run: Insertion sort: ordered with 10 runs
3.125304
Size: 4000
2021-09-26 18:57:46 INFO  Benchmark_Timer - Begin run: Insertion sort: ordered with 10 runs
12.928644600000002
Size: 8000
2021-09-26 18:57:46 INFO  Benchmark_Timer - Begin run: Insertion sort: ordered with 10 runs
48.3720463
Size: 16000
2021-09-26 18:57:47 INFO  Benchmark_Timer - Begin run: Insertion sort: ordered with 10 runs
200.4515561
```

```
============== Sort reverse-ordered arrays ==============
Size: 500
2021-09-26 18:57:49 INFO  Benchmark_Timer - Begin run: Insertion sort: ordered with 10 runs
0.503272
Size: 1000
2021-09-26 18:57:49 INFO  Benchmark_Timer - Begin run: Insertion sort: ordered with 10 runs
2.0012676
Size: 2000
2021-09-26 18:57:49 INFO  Benchmark_Timer - Begin run: Insertion sort: ordered with 10 runs
8.065994
Size: 4000
2021-09-26 18:57:49 INFO  Benchmark_Timer - Begin run: Insertion sort: ordered with 10 runs
34.8252633
Size: 8000
2021-09-26 18:57:50 INFO  Benchmark_Timer - Begin run: Insertion sort: ordered with 10 runs
129.7315774
Size: 16000
2021-09-26 18:57:52 INFO  Benchmark_Timer - Begin run: Insertion sort: ordered with 10 runs
512.3849207000001
```

n	Random	Ordered	Partially-ordered	Reverse-ordered
500	1.243178	0.0045949	0.2507414	0.503272
1000	1.4672772	0.0084913	0.7731105	2.0012676
2000	5.8056143	0.0157823	3.125304	8.065994
4000	23.8653991	0.0347912	12.9286446	34.8252633
8000	77.1327676	0.0582296	48.3720463	129.7315774
16000	259.4787478	0.1159774	200.4515561	512.3849207

- Unit Tests Result: