

Computer Science 172 Lab 7: Sorting

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Console Outputs

1kints

```
|dhcp-10-5-26-132:Lab7 njrom$ java Sorting 1kints.txt 0
|Arrays.sort() (Java Default) a      0.0  20180401_213403  nromano2  1kints.txt
|Arrays.sort() (Java Default) b      0.0  20180401_213403  nromano2  1kints.txt
|Arrays.sort() (Java Default) c      0.0  20180401_213403  nromano2  1kints.txt
|Arrays.sort() (Java Default) d      0.0  20180401_213403  nromano2  1kints.txt
dhcp-10-5-26-132:Lab7 njrom$ java Sorting 1kints.txt 1
|Bubble Sort a      6.0  20180401_213406  nromano2  1kints.txt
|Bubble Sort b      1.0  20180401_213406  nromano2  1kints.txt
|Bubble Sort c      2.0  20180401_213406  nromano2  1kints.txt
|Bubble Sort d      5.0  20180401_213406  nromano2  1kints.txt
dhcp-10-5-26-132:Lab7 njrom$ java Sorting 1kints.txt 2
|Selection Sort a   6.0  20180401_213409  nromano2  1kints.txt
|Selection Sort b   1.0  20180401_213409  nromano2  1kints.txt
|Selection Sort c   4.0  20180401_213409  nromano2  1kints.txt
|Selection Sort d   3.0  20180401_213409  nromano2  1kints.txt
dhcp-10-5-26-132:Lab7 njrom$ java Sorting 1kints.txt 3
|Insertion Sort a   3.0  20180401_213413  nromano2  1kints.txt
|Insertion Sort b   0.0  20180401_213413  nromano2  1kints.txt
|Insertion Sort c   4.0  20180401_213413  nromano2  1kints.txt
|Insertion Sort d   0.0  20180401_213413  nromano2  1kints.txt
dhcp-10-5-26-132:Lab7 njrom$ java Sorting 1kints.txt 4
|Mergesort a        0.0  20180401_213416  nromano2  1kints.txt
|Mergesort b        0.0  20180401_213416  nromano2  1kints.txt
|Mergesort c        0.0  20180401_213416  nromano2  1kints.txt
|Mergesort d        0.0  20180401_213416  nromano2  1kints.txt
dhcp-10-5-26-132:Lab7 njrom$ java Sorting 1kints.txt 5
|Quicksort a       0.0  20180401_213419  nromano2  1kints.txt
|Quicksort b       0.0  20180401_213419  nromano2  1kints.txt
|Quicksort c       1.0  20180401_213419  nromano2  1kints.txt
|Quicksort d       0.0  20180401_213419  nromano2  1kints.txt
dhcp-10-5-26-132:Lab7 njrom$ |
```

2kints

```
[dhcp-10-5-26-132:Lab7 njrom$ java Sorting 2kints.txt 0
Arrays.sort() (Java Default) a      1.0  20180401_213844  nromano2  2kints.txt
Arrays.sort() (Java Default) b      0.0  20180401_213844  nromano2  2kints.txt
Arrays.sort() (Java Default) c      0.0  20180401_213844  nromano2  2kints.txt
Arrays.sort() (Java Default) d      1.0  20180401_213844  nromano2  2kints.txt
[dhcp-10-5-26-132:Lab7 njrom$ java Sorting 2kints.txt 1
Bubble Sort a      20.0  20180401_213849  nromano2  2kints.txt
Bubble Sort b      20.0  20180401_213849  nromano2  2kints.txt
Bubble Sort c      11.0  20180401_213849  nromano2  2kints.txt
Bubble Sort d      17.0  20180401_213849  nromano2  2kints.txt
[dhcp-10-5-26-132:Lab7 njrom$ java Sorting 2kints.txt 2
Selection Sort a   14.0  20180401_213913  nromano2  2kints.txt
Selection Sort b   16.0  20180401_213913  nromano2  2kints.txt
Selection Sort c   20.0  20180401_213913  nromano2  2kints.txt
Selection Sort d   11.0  20180401_213913  nromano2  2kints.txt
[dhcp-10-5-26-132:Lab7 njrom$ java Sorting 2kints.txt 3
Insertion Sort a   10.0  20180401_213916  nromano2  2kints.txt
Insertion Sort b   0.0   20180401_213916  nromano2  2kints.txt
Insertion Sort c   15.0  20180401_213916  nromano2  2kints.txt
Insertion Sort d   2.0   20180401_213916  nromano2  2kints.txt
[dhcp-10-5-26-132:Lab7 njrom$ java Sorting 2kints.txt 4
Mergesort a        2.0   20180401_213918  nromano2  2kints.txt
Mergesort b        5.0   20180401_213918  nromano2  2kints.txt
Mergesort c        1.0   20180401_213918  nromano2  2kints.txt
Mergesort d        1.0   20180401_213918  nromano2  2kints.txt
[dhcp-10-5-26-132:Lab7 njrom$ java Sorting 2kints.txt 5
Quicksort a       1.0   20180401_213920  nromano2  2kints.txt
Quicksort b       0.0   20180401_213920  nromano2  2kints.txt
Quicksort c       0.0   20180401_213920  nromano2  2kints.txt
Quicksort d       0.0   20180401_213920  nromano2  2kints.txt
dhcp-10-5-26-132:Lab7 njrom$ |
```

4kints

```
[dhcp-10-5-26-132:Lab7 njrom$ java Sorting 4kints.txt 0
Arrays.sort() (Java Default) a      1.0  20180401_214029  nromano2  4kints.txt
Arrays.sort() (Java Default) b      0.0  20180401_214029  nromano2  4kints.txt
Arrays.sort() (Java Default) c      1.0  20180401_214029  nromano2  4kints.txt
Arrays.sort() (Java Default) d      0.0  20180401_214029  nromano2  4kints.txt
[dhcp-10-5-26-132:Lab7 njrom$ java Sorting 4kints.txt 1
Bubble Sort a      47.0  20180401_214032  nromano2  4kints.txt
Bubble Sort b      66.0  20180401_214032  nromano2  4kints.txt
Bubble Sort c      59.0  20180401_214032  nromano2  4kints.txt
Bubble Sort d      53.0  20180401_214032  nromano2  4kints.txt
[dhcp-10-5-26-132:Lab7 njrom$ java Sorting 4kints.txt 2
Selection Sort a   44.0  20180401_214034  nromano2  4kints.txt
Selection Sort b   10.0  20180401_214034  nromano2  4kints.txt
Selection Sort c   173.0 20180401_214035  nromano2  4kints.txt
Selection Sort d   18.0  20180401_214035  nromano2  4kints.txt
[dhcp-10-5-26-132:Lab7 njrom$ java Sorting 4kints.txt 3
Insertion Sort a   31.0  20180401_214038  nromano2  4kints.txt
Insertion Sort b   0.0   20180401_214038  nromano2  4kints.txt
Insertion Sort c   51.0  20180401_214038  nromano2  4kints.txt
Insertion Sort d   6.0   20180401_214038  nromano2  4kints.txt
[dhcp-10-5-26-132:Lab7 njrom$ java Sorting 4kints.txt 4
Mergesort a        3.0   20180401_214040  nromano2  4kints.txt
Mergesort b        1.0   20180401_214040  nromano2  4kints.txt
Mergesort c        1.0   20180401_214040  nromano2  4kints.txt
Mergesort d        1.0   20180401_214040  nromano2  4kints.txt
[dhcp-10-5-26-132:Lab7 njrom$ java Sorting 4kints.txt 5
Quicksort a       2.0   20180401_214043  nromano2  4kints.txt
Quicksort b       0.0   20180401_214043  nromano2  4kints.txt
Quicksort c       1.0   20180401_214043  nromano2  4kints.txt
Quicksort d       0.0   20180401_214043  nromano2  4kints.txt
dhcp-10-5-26-132:Lab7 njrom$ |
```

8kints

```
|dhcp-10-5-26-132:Lab7 njrom$ java Sorting 8kints.txt 0
Arrays.sort() (Java Default) a      1.0  20180401_214227  nromano2  8kints.txt
Arrays.sort() (Java Default) b      0.0  20180401_214227  nromano2  8kints.txt
Arrays.sort() (Java Default) c      1.0  20180401_214227  nromano2  8kints.txt
Arrays.sort() (Java Default) d      0.0  20180401_214227  nromano2  8kints.txt
|dhcp-10-5-26-132:Lab7 njrom$ java Sorting 8kints.txt 1
Bubble Sort a    164.0  20180401_214229  nromano2  8kints.txt
Bubble Sort b    137.0  20180401_214229  nromano2  8kints.txt
Bubble Sort c    90.0   20180401_214229  nromano2  8kints.txt
Bubble Sort d    28.0   20180401_214229  nromano2  8kints.txt
|dhcp-10-5-26-132:Lab7 njrom$ java Sorting 8kints.txt 2
Selection Sort a 99.0   20180401_214232  nromano2  8kints.txt
Selection Sort b 162.0   20180401_214232  nromano2  8kints.txt
Selection Sort c 46.0   20180401_214232  nromano2  8kints.txt
Selection Sort d 32.0   20180401_214232  nromano2  8kints.txt
|dhcp-10-5-26-132:Lab7 njrom$ java Sorting 8kints.txt 3
Insertion Sort a 68.0   20180401_214235  nromano2  8kints.txt
Insertion Sort b 0.0    20180401_214235  nromano2  8kints.txt
Insertion Sort c 117.0   20180401_214235  nromano2  8kints.txt
Insertion Sort d 1.0    20180401_214235  nromano2  8kints.txt
|dhcp-10-5-26-132:Lab7 njrom$ java Sorting 8kints.txt 4
Mergesort a     3.0   20180401_214237  nromano2  8kints.txt
Mergesort b     2.0   20180401_214237  nromano2  8kints.txt
Mergesort c     2.0   20180401_214237  nromano2  8kints.txt
Mergesort d     2.0   20180401_214237  nromano2  8kints.txt
|dhcp-10-5-26-132:Lab7 njrom$ java Sorting 8kints.txt 5
Quicksort a    2.0   20180401_214241  nromano2  8kints.txt
Quicksort b    0.0   20180401_214241  nromano2  8kints.txt
Quicksort c    1.0   20180401_214241  nromano2  8kints.txt
Quicksort d    1.0   20180401_214241  nromano2  8kints.txt
dhcp-10-5-26-132:Lab7 njrom$ |
```

16kints

```
[dhcp-10-5-26-132:Lab7 njrom$ java Sorting 16kints.txt 0
Arrays.sort() (Java Default) a      2.0  20180401_214409  nromano2  16kints.txt
Arrays.sort() (Java Default) b      1.0  20180401_214409  nromano2  16kints.txt
Arrays.sort() (Java Default) c      0.0  20180401_214409  nromano2  16kints.txt
Arrays.sort() (Java Default) d      0.0  20180401_214409  nromano2  16kints.txt
[dhcp-10-5-26-132:Lab7 njrom$ java Sorting 16kints.txt 1
Bubble Sort a    528.0  20180401_214416  nromano2  16kints.txt
Bubble Sort b    234.0  20180401_214416  nromano2  16kints.txt
Bubble Sort c    147.0  20180401_214416  nromano2  16kints.txt
Bubble Sort d    113.0  20180401_214417  nromano2  16kints.txt
[dhcp-10-5-26-132:Lab7 njrom$ java Sorting 16kints.txt 2
Selection Sort a 238.0  20180401_214419  nromano2  16kints.txt
Selection Sort b 193.0  20180401_214419  nromano2  16kints.txt
Selection Sort c 97.0   20180401_214419  nromano2  16kints.txt
Selection Sort d 80.0   20180401_214419  nromano2  16kints.txt
[dhcp-10-5-26-132:Lab7 njrom$ java Sorting 16kints.txt 3
Insertion Sort a 182.0  20180401_214427  nromano2  16kints.txt
Insertion Sort b 0.0    20180401_214427  nromano2  16kints.txt
Insertion Sort c 183.0  20180401_214427  nromano2  16kints.txt
Insertion Sort d 6.0    20180401_214427  nromano2  16kints.txt
[dhcp-10-5-26-132:Lab7 njrom$ java Sorting 16kints.txt 4
Mergesort a      6.0   20180401_214433  nromano2  16kints.txt
Mergesort b      4.0   20180401_214433  nromano2  16kints.txt
Mergesort c      4.0   20180401_214433  nromano2  16kints.txt
Mergesort d      5.0   20180401_214433  nromano2  16kints.txt
[dhcp-10-5-26-132:Lab7 njrom$ java Sorting 16kints.txt 5
Quicksort a     3.0   20180401_214436  nromano2  16kints.txt
Quicksort b     1.0   20180401_214436  nromano2  16kints.txt
Quicksort c     1.0   20180401_214436  nromano2  16kints.txt
Quicksort d     2.0   20180401_214436  nromano2  16kints.txt
dhcp-10-5-26-132:Lab7 njrom$
```

32kints

```
[dhcp-10-5-26-132:Lab7 njrom$ java Sorting 32kints.txt 0
Arrays.sort() (Java Default) a      3.0  20180401_214516  nromano2  32kints.txt
Arrays.sort() (Java Default) b      1.0  20180401_214516  nromano2  32kints.txt
Arrays.sort() (Java Default) c      2.0  20180401_214516  nromano2  32kints.txt
Arrays.sort() (Java Default) d      1.0  20180401_214516  nromano2  32kints.txt
[dhcp-10-5-26-132:Lab7 njrom$ java Sorting 32kints.txt 1
Bubble Sort a    1938.0  20180401_214521  nromano2  32kints.txt
Bubble Sort b    790.0   20180401_214521  nromano2  32kints.txt
Bubble Sort c    1125.0  20180401_214523  nromano2  32kints.txt
Bubble Sort d    520.0   20180401_214523  nromano2  32kints.txt
[dhcp-10-5-26-132:Lab7 njrom$ java Sorting 32kints.txt 2
Selection Sort a  557.0  20180401_214527  nromano2  32kints.txt
Selection Sort b  538.0  20180401_214528  nromano2  32kints.txt
Selection Sort c  367.0  20180401_214528  nromano2  32kints.txt
Selection Sort d  321.0  20180401_214528  nromano2  32kints.txt
[dhcp-10-5-26-132:Lab7 njrom$ java Sorting 32kints.txt 3
Insertion Sort a  216.0  20180401_214532  nromano2  32kints.txt
Insertion Sort b  0.0   20180401_214532  nromano2  32kints.txt
Insertion Sort c  356.0  20180401_214532  nromano2  32kints.txt
Insertion Sort d  20.0   20180401_214532  nromano2  32kints.txt
[dhcp-10-5-26-132:Lab7 njrom$ java Sorting 32kints.txt 4
Mergesort a      11.0   20180401_214534  nromano2  32kints.txt
Mergesort b      9.0    20180401_214534  nromano2  32kints.txt
Mergesort c      6.0    20180401_214534  nromano2  32kints.txt
Mergesort d      24.0   20180401_214534  nromano2  32kints.txt
[dhcp-10-5-26-132:Lab7 njrom$ java Sorting 32kints.txt 5
Quicksort a     7.0    20180401_214537  nromano2  32kints.txt
Quicksort b     0.0    20180401_214537  nromano2  32kints.txt
Quicksort c     1.0    20180401_214537  nromano2  32kints.txt
Quicksort d     2.0    20180401_214537  nromano2  32kints.txt
dhcp-10-5-26-132:Lab7 njrom$
```

1Mints

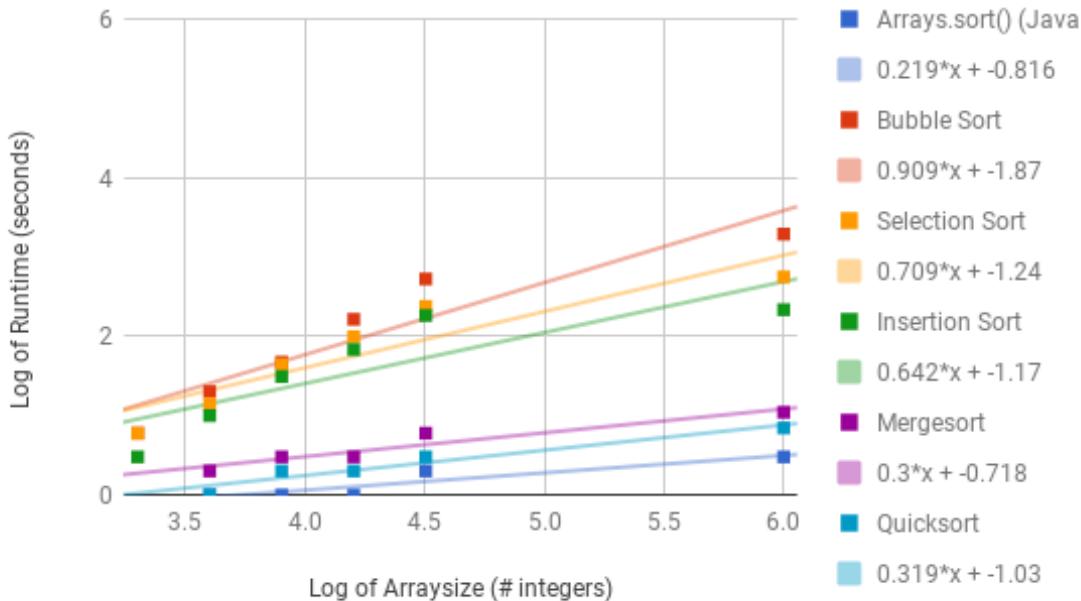
```
Arrays.sort() (Java Default) a    78.0  20180401_221947  nromano2  1Mints.txt
Arrays.sort() (Java Default) b    18.0  20180401_221948  nromano2  1Mints.txt
Arrays.sort() (Java Default) c    6.0   20180401_221948  nromano2  1Mints.txt
Arrays.sort() (Java Default) d    18.0  20180401_221948  nromano2  1Mints.txt
dhcp-10-5-26-132:Lab7 njrom$ |
Insertion Sort a 139214.0  20180401_221009  nromano2  1Mints.txt
Insertion Sort b  4.0   20180401_221009  nromano2  1Mints.txt
Insertion Sort c 271215.0  20180401_221441  nromano2  1Mints.txt
Insertion Sort d  24146.0  20180401_221505  nromano2  1Mints.txt
dhcp-10-5-26-132:Lab7 njrom$ |
```

```
^Cdhcp-10-5-26-132:Lab7 njrom$ java Sorting 1Mints.txt 4
Mergesort a      232.0  20180401_215035  nromano2  1Mints.txt
Mergesort b      98.0   20180401_215035  nromano2  1Mints.txt
Mergesort c      87.0   20180401_215035  nromano2  1Mints.txt
Mergesort d      94.0   20180401_215036  nromano2  1Mints.txt
dhcp-10-5-26-132:Lab7 njrom$ java Sorting 1Mints.txt 5
Quicksort a     124.0  20180401_215039  nromano2  1Mints.txt
Quicksort b     18.0   20180401_215040  nromano2  1Mints.txt
Quicksort c     20.0   20180401_215040  nromano2  1Mints.txt
Quicksort d     37.0   20180401_215040  nromano2  1Mints.txt
dhcp-10-5-26-132:Lab7 njrom$ |
```

Graphs and Analysis

Array A: Nonsorted Integers						
	Arrays.sort() (Java Default)	Bubble Sort	Selection Sort	Insertion Sort	Mergesort	Quicksort
1kints	0	6	6	3	0	0
2kints	1	20	14	10	2	1
4kints	1	47	44	31	3	2
8kints	1	164	99	68	3	2
16kints	2	528	238	182	6	3
32kints	3	1938	557	216	11	7
1Mints	78			139214	232	124

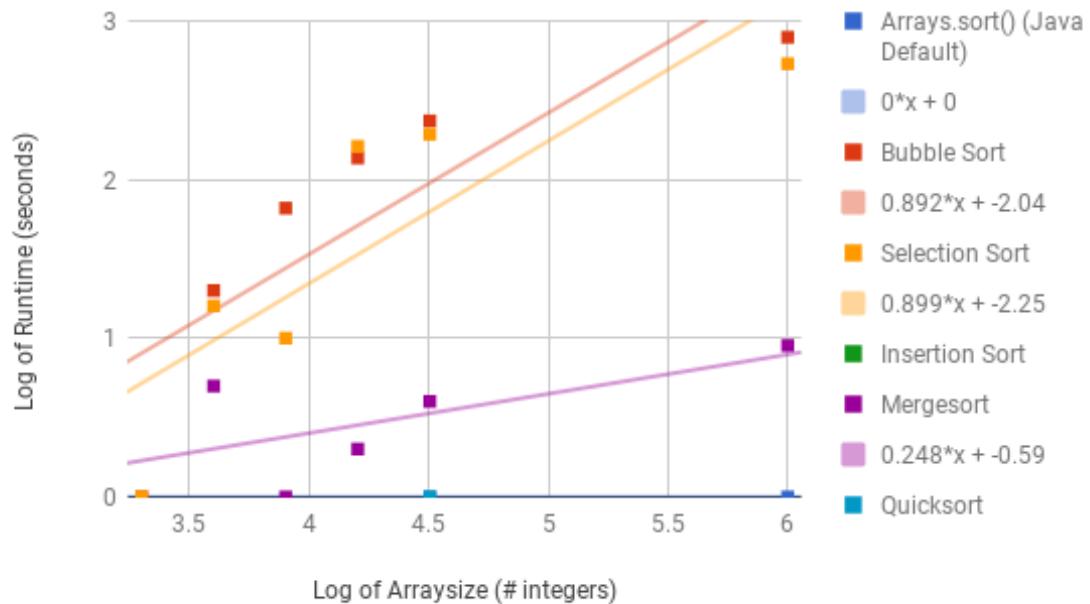
Runtime for Array A: Nonsorted Integers



The results for nonsorted integers separate out the $O(n^2)$ sorting algorithms (Selection, Bubble, and insertion) from the $O(n \log n)$ algorithms. I plotted this data as a log log plot to see if I could accurately get the x^n exponent (the slope of the log log plot) to be around 2 for the $O(n^2)$ algorithms. Our data did not lead to n 's near 2, but still clearly shows the difference between the n^2 and $n \log n$ algorithms.

Array B: Sorted Integers						
	Arrays.sort() (Java Default)	Bubble Sort	Selection Sort	Insertion Sort	Mergesort	Quicksort
1kints	0	1	1	0	0	0
2kints	0	20	16	0	5	0
4kints	0	66	10	0	1	0
8kints	0	137	162	0	2	0
16kints	1	234	193	0	4	1
32kints	1	790	538	0	9	0
1Mints	18			4	98	18

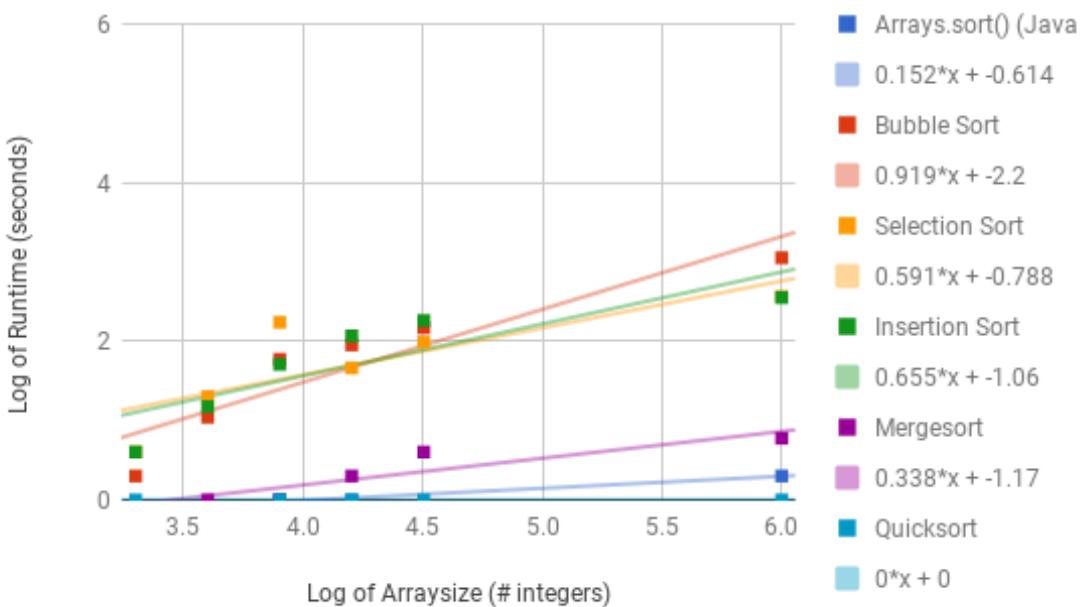
Runtime for Array B: Sorted Integers



For sorted integers we can see that both `Arrays.sort()` and insertion sort don't have any visible data points on the graph. This is because this is a log log plot and is not showing cases where the time was equal to zero. This shows how both insertion sort and `Arrays.sort` have a constant time operation for already sorted arrays. Quick sort also seemed to have incredibly low times for this sorted array. This is strange because the worst case scenario generally for a quick sort is with an already sorted array. Because in my quick sort algorithm I pick the middle pivot this isn't as obvious, but if we were to go and sort much larger arrays we would most likely see the $O(n^2)$ growth emerge.

Array C: Sorted Integers in Reverse Order						
	Arrays.sort() (Java Default)	Bubble Sort	Selection Sort	Insertion Sort	Mergesort	Quicksort
1kints	0	2	4	4	0	1
2kints	0	11	20	15	1	0
4kints	1	59	173	51	1	1
8kints	1	90	46	117	2	1
16kints	0	147	97	183	4	1
32kints	2	1125	367	356	6	1
1Mints	6			271215	87	20

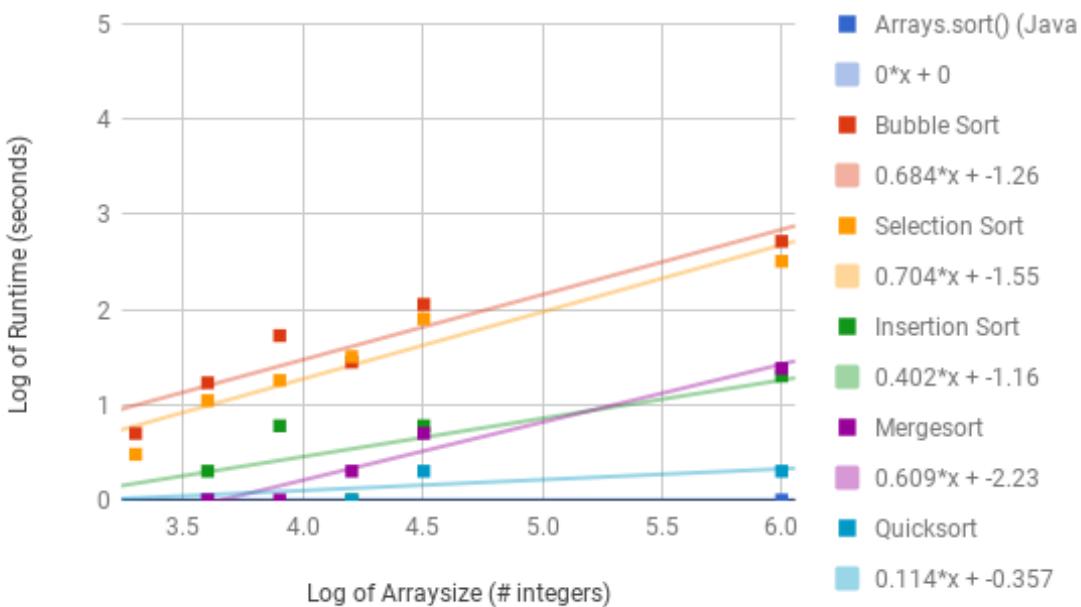
Runtime for Array C: Sorted Integers in Reverse Order



The java default algorithm and QuickSort proved to deal with the reverse order sorted integers much better than our other algorithms. In this plot we see the similar divide separating the n^2 algorithms from the $n \log(n)$ ones.

Array D: Almost Sorted Integers						
	Arrays.sort() (Java Default)	Bubble Sort	Selection Sort	Insertion Sort	Mergesort	Quicksort
1kints	0	5	3	0	0	0
2kints	1	17	11	2	1	0
4kints	0	53	18	6	1	0
8kints	0	28	32	1	2	1
16kints	0	113	80	6	5	2
32kints	1	520	321	20	24	2
1Mints	18			24146	94	37

Runtime for Array D: Almost Sorted Integers



Insertion sort performed particularly well compared to the other $O(n^2)$ algorithms here, this is probably because it is more likely to correct the few swapped values in less passes than bubble or selection sort.