Course: CSC 220.02
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Assignment Number: 04
Assignment Due Date & Time: 04-19-2020 at 11:55 PM

PART A – Introduction to Sorting, 9 points

Please use this array of integers for the A.1, A.2, and A.3 problems:

9 1 2 4 3 5 6 2 9 8 5 7

- Use pen & paper to show our work and answers. We can scan/snapshot our work and include the images in our report.

- Use code to demonstrate our approaches and solutions. Submit code and include screenshots of output in our report.

- Each of these problems (A.1, A.2, and A.3) is worth **3 points**.

1. Show the contents of the array each time a **selection sort** changes it while sorting the array into **ascending order**.

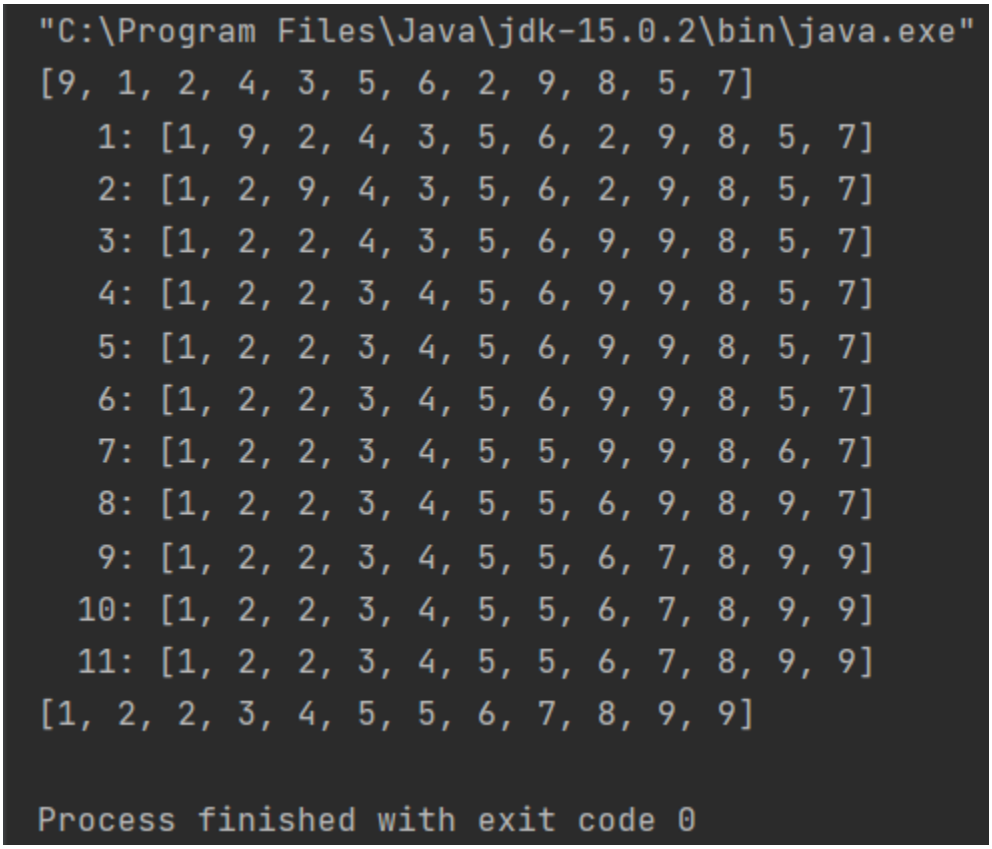
- See assignment04PartA/A1 in the attached files for the code.

  Below is the screenshot of the output demonstrating the contents of the array each time the algorithm sorts the array.

  In insertion sort, the algorithm starts at the zeroth element and looks for the element with the lowest value in the array.

Then, it swaps the zeroth element with those of the lowest. In the given array, the lowest value is 1. As such, it swaps 1 with 9 (the zeroth element) in the first iteration.

Insertion sort repeats this process on the next element (swapping 9, the first element with 2, the element with the next lowest value in the array), and continues to do so until it reaches the end of the array. Whereby each iteration guarantees that those to the left of the current index are sorted.



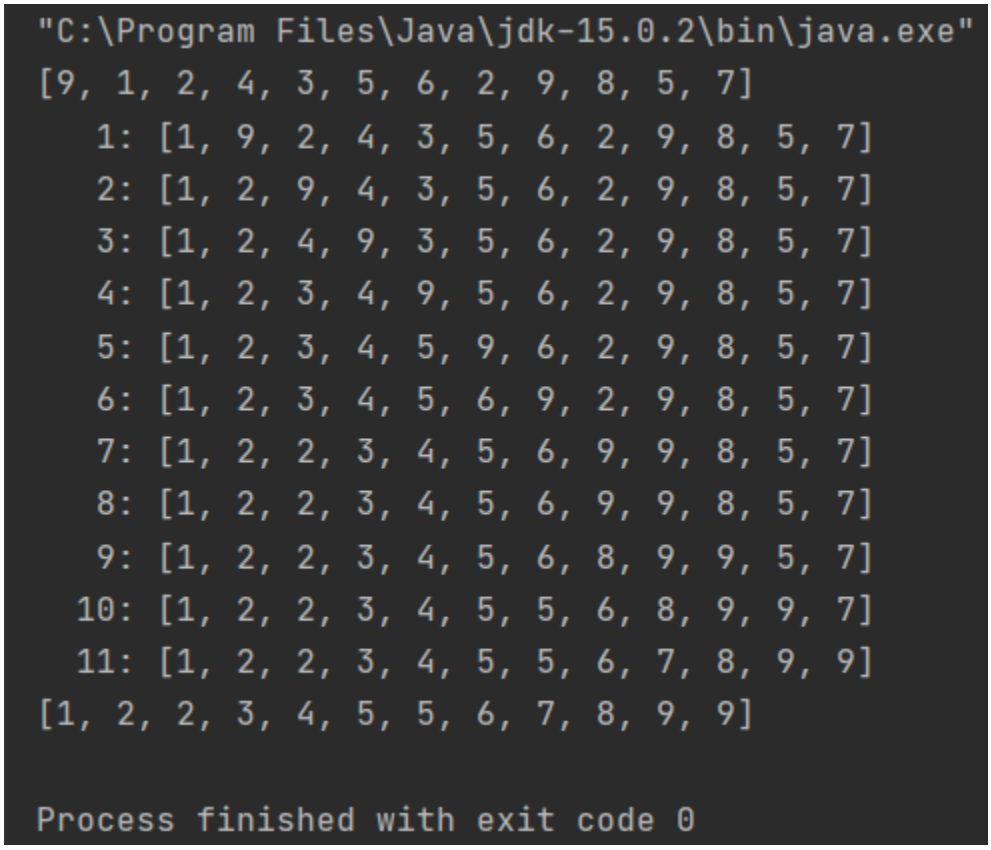
2. Show the contents of the array each time an **insertion sort** changes it while sorting the array into **ascending order**.

    - See assignment04PartA/A2 in the attached files for the code.

Below is the screenshot of the output demonstrating the contents of the array each time the algorithm sorts the array.

In insertion sort, the algorithm starts at the zeroth element and considers it to be a sublist of the given array.

Then, it moves on to the next element and inserts it into the sublist, sorting it if needed. In the given array, the zeroth element, 9, is a singleton. Then, to insert the next element, 1, into the sublist, it swaps the position with 9 to ensure that the sublist is sorted in order. The process continues where the elements adjacent to the sublist are added and are sorted each time (if needed) until the final element in the array is included in the sublist.



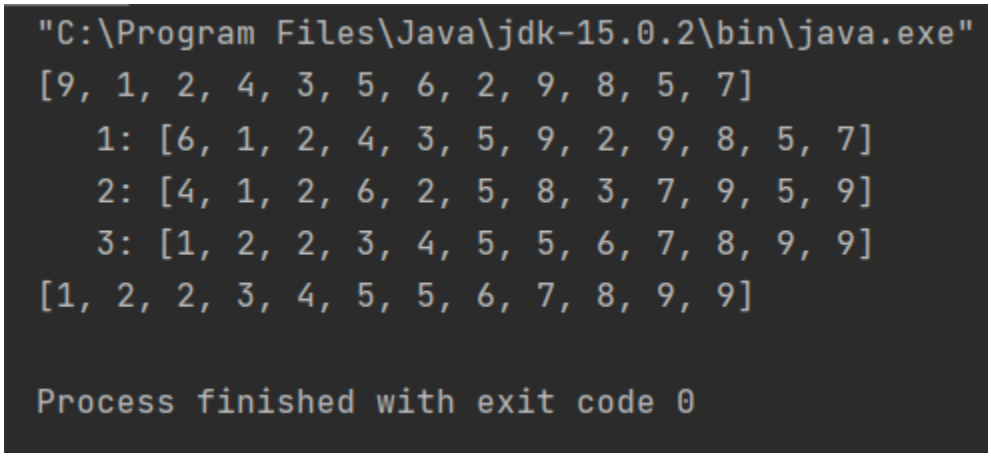
3. Show the contents of the array each time a **Shell sort** changes it while sorting the array into **ascending order**.

   - See assignment04PartA/A3 in the attached files for the code.

     Below is the screenshot of the output demonstrating the contents of the array each time the algorithm sorts the array.

     In Shell sort, the algorithm starts by splitting the array into equally spaced sublists and sorting them separately using insertion sort.

     In the given array, there are 12 elements in total. As such, the first iteration splits the array into six different segments. Where it then sorts the divided segments in an incremental order. In each of these segments, the elements are at least six elements apart. Then, the separation halves again, sorting every third element, repeating until the separation is one (no separation; in this case, it repeats a total of three times). Where the last separation is simply an insertion sort of the entire array. The difference between Shell and insertion sort is that the final sort is quicker when the sublists are partially sorted.



PART B – Sorting, 11 points

1. **--- 3 points ---** Suppose we want to find the largest entry in an unsorted array of n entries. Algorithm A searches the entire array sequentially and records the largest entry seen so far. Algorithm B sorts the array into descending order and then reports the first entry as the largest. Compare the time efficiency of the two approaches. *Coding is not required but highly recommended.*

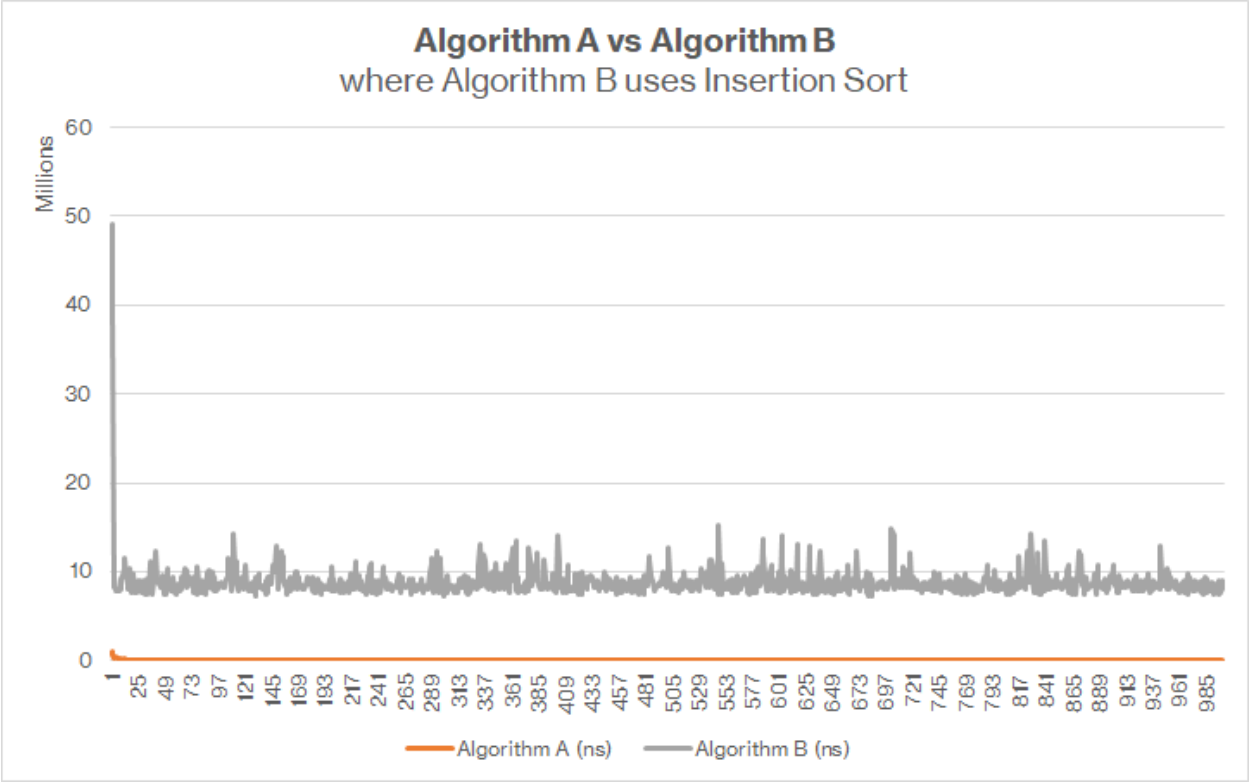
    - See assignment04PartA/B1 in the attached files for the time comparison.

      By observation, we are able to see that Algorithm A is much faster than those of Algorithm B. This is because Algorithm B makes sure that all of the elements in an array are sorted, which means more comparisons are being made. While Algorithm A compares the value of each element exactly once against its highest recorded value.

      Below is the graph of the time taken by Algorithm A and Algorithm B to sort an array of 10,000 randomly-generated integers over 10,000 trials, where the arrays are generated on each trial.

      We can see clearly, even with varying generated arrays, that the time taken by Algorithm A is consistently lower than those of Algorithm B.

      The scale of the time taken by Algorithm A is so insignificant compared to those of Algorithm B such that the thickness of its plot is larger than the value represented.



2. **--- 8 points ---** Consider an **n by n** array of integer values. Write an algorithm to sort the rows of the array by their first value.

   The starter code for this problem is provided in the **Assignment-04-Code.zip** archive. Our output must be **identical** to the output to the right.

   - See assignment04PartB2 in the attached files.

PART C – Queues, Deques, and Priority Queues, 15 points

1. **--- 5 points ---** After **each of the following statements executes**, what are the contents of the **queue**? Please explain.

   - See assignment04PartC1 in the attached files for the code.

   - `QueueInterface<String> myQueue = new LinkedQueue<>();`

`[]`

Nothing, instantiating queue.

- **`myQueue.enqueue("Jane");`**

  `[Jane]`

  Adds “Jane” to the end of the queue.

- **`myQueue.enqueue("Jess");`**

  `[Jane, Jess]`

  Adds “Jess” to the end of the queue.

- **`myQueue.enqueue("Jon");`**

  `[Jane, Jess, Jon]`

  Adds “Jon” to the end of the queue.

- **`myQueue.enqueue(myQueue.dequeue());`**

  `[Jess, Jon, Jane]`

  Removes “Jane” from the front of the queue. Then, add it to the end.

- **`myQueue.enqueue(myQueue.getFront());`**

  `[Jess, Jon, Jane, Jess]`

  Gets “Jess” from the front of the queue. Then, add it to the end.

- **`myQueue.enqueue("Jim");`**

`[Jess, Jon, Jane, Jess, Jim]`

Adds “Jim” to the end of the queue.

- **`String name = myQueue.dequeue();`**

  `[Jon, Jane, Jess, Jim]`

  Removes “Jess” from the front of the queue.

- **`myQueue.enqueue(myQueue.getFront());`**

  `[Jon, Jane, Jess, Jim, Jon]`

  Gets “John” from the front of the queue. Then, add it to the end.

2. **- 5 pts -** After **<u>each of the following statements</u>** executes, what are the contents of the deque? Please explain.

   - See assignment04PartC2 in the attached files for the code.

   - **`DequeInterface<String> myDeque = new LinkedDeque<>();`**

     `[]`

     Nothing, instantiating deque.

   - **`myDeque.addToFront("Jim");`**

     `[Jim]`

     Adds “Jim” to the front of the deque.

   - **`myDeque.addToFront("Jess");`**

`[Jess, Jim]`

Adds “Jess” to the front of the deque.

- **`myDeque.addToBack("Jen");`**

  `[Jess, Jim, Jen]`

  Adds “Jen” to the back of the deque.

- **`myDeque.addToBack("Josh");`**

  `[Jess, Jim, Jen, Josh]`

  Adds “Josh” to the back of the deque.

- **`String name = myDeque.removeFront();`**

  `[Jim, Jen, Josh]`

  Removes “Jess” from the front of the deque.

- **`myDeque.addToBack(name);`**

  `[Jim, Jen, Josh, Jess]`

  Adds “Jess” from the stored value to the back of the deque.

- **`myDeque.addToBack(myDeque.getFront());`**

  `[Jim, Jen, Josh, Jess, Jim]`

  Gets “Jim” from the front of the deque. Then, add it to the back.

- **`myDeque.addToFront(myDeque.removeBack());`**

`[Jim, Jim, Jen, Josh, Jess]`

Removes “Jim” from the back of the deque. Then, add it to the front.

- **`myDeque.addToFront(myDeque.getBack());`**

`[Jess, Jim, Jim, Jen, Josh, Jess]`

Get “Jess” from the front of the deque. Then, add it to the front.

3. **- 5 pts -** After **<u>each of the following statements executes</u>**, what are the contents of the priority queue? Please explain.

- See assignment04PartC3 in the attached files for the code.
- **`PriorityQueueInterface<String> myPriorityQueue = new LinkedPriorityQueue<>();`**

`[]`

Nothing, instantiating queue.

- **`myPriorityQueue.add("Jim");`**

`[Jim]`

Adds “Jim” to the queue.

- **`myPriorityQueue.add("Josh");`**

`[Jim, Josh]`

Adds “Josh” to the queue. Goes after “Jim” due to alphabetical order.

- **`myPriorityQueue.add("Jon");`**

`[Jim, Jon, Josh]`

Adds “Jon” to the queue. Goes after “Jim” and before “Josh” due to alphabetical order.

- **`myPriorityQueue.add("Jane");`**

  `[Jane, Jim, Jon, Josh]`

  Adds “Jane” to the queue. Goes before “Jim” due to alphabetical order.

- **`String name = myPriorityQueue.remove();`**

  `[Jim, Jon, Josh]`

  Removes “Jane” from the queue. Gets removed due to having highest priority in alphabetical order.

- **`myPriorityQueue.add(name);`**

  `[Jane, Jim, Jon, Josh]`

  Adds “Jane” from the stored value to the queue. Goes before “Jim” due to alphabetical order.

- **`myPriorityQueue.add(myPriorityQueue.peek());`**

  `[Jane, Jane, Jim, Jon, Josh]`

  Gets “Jane” by peeking at the top of the priority queue. Gets returned due to having highest priority in alphabetical order. Then, add it to the queue. Goes next to existing “Jane” due to alphabetical order.

- **`myPriorityQueue.add("Jose");`**

`[Jane, Jane, Jim, Jon, Jose, Josh]`

Adds “Jose” to the queue. Goes before “Josh” and after “Jim” due to alphabetical order.

- **`myPriorityQueue.remove();`**

  `[Jane, Jim, Jon, Jose, Josh]`

  Removes “Jane” from the queue. Gets removed due to having highest priority in alphabetical order.

It is OK to assume that the alphabetically earliest string has the highest priority.

PART D – Queue and Deque, Circular Doubly Linked Chain, 20 points

Use a circular doubly linked chain to **implement** the ADT deque.

In a **doubly linked chain**, the first and last nodes each contain one null reference, since the first node has no previous node and the last node has no node after it. In a circular doubly linked chain, the first node references the last node, and the last node references the first. Only one external reference is necessary—a reference to the first node—since we can quickly get to the last node from the first node.

The code for this problem is provided in the **Assignment-04-Code.zip** archive. Our output must be **identical** to the output to the right.

- See assignment04PartD in the attached files.

  Note that the order of the output may not match due to a strange race condition between the output streams of standard out and standard error. This behavior may vary

between different environments. This output is determined by the provided driver file and cannot be edited as such.

The expected output may be obtained by running the code driver file several times. In the process, you may observe that the output varies between each run despite being a linear program with no randomization element.

PART E – Priority Queue, 20 points

The San Francisco State University's One Stop Student Services Center asks us to recommend solutions for their service lines.

- The starter code for this problem is provided in the Assignment-04-Code.zip archive.
- Our output must be identical to the complete output provided in the ZIP archive: ***PartE-The_Complete_Sample_Run.pdf***

- *The right table is a portion of the output for preview purposes. It is NOT the complete output.*
- *It is a good idea to analyze the complete output thoroughly before programming a solution.*

- See assignment04PartE in the attached files.