**Data Structures (2028C) – Spring 2022 – Lab 12**

***Topics covered: Sorting***

*Lab due: Sunday****, April 24th 11:59 PM for Monday Lab, Tuesday April 26th 11:59 PM for Wednesday lab.***

**Objective:**

The objective of this Lab is to investigate different sorting algorithms.

**Scenario:**

In this assignment, we are going to be investigating the actual performance of different sorting methods. Additionally, we will implement 1 sorting method on a linked list. This needs to be written using C++.

**Requirements:**

1. Create a program that generate an array of sizes n= 10, 100, 500, 5000, 25,000, and 100,000 items. Your program should populate those arrays with randomly generated integers with a value between 0 and the 2n where n is the size of the array. Create an implementation for the following sort operations.
   1. Bubble sort
   2. Insertion sort
   3. Merge-sort
   4. Quicksort
   5. Counting sort
   6. Radix-sort
2. Test each of the sort operations and record the time the sort takes to complete. You should test each on the same unsorted array to get the best comparison. You should do this for each array size (from requirement 1) a minimum of 10 times. Your test should use the chrono library’s [high\_resolution\_clock](http://www.cplusplus.com/reference/chrono/high_resolution_clock/) class. The following example of how to do this in nanoseconds is found on [Stack Overflow](http://stackoverflow.com/questions/3220477/how-to-use-clock-in-c). Only the time in the 7 sort functions should be measured.  
   1. #include <iostream>
   2. #include <chrono>
   3. typedef std::chrono::high\_resolution\_clock Clock;
   4. int main()
   5. {
   6. auto t1 = Clock::now();
   7. auto t2 = Clock::now();
   8. std::cout << "Delta t2-t1: "
   9. << std::chrono::duration\_cast<std::chrono::nanoseconds>(t2 - t1).count()
   10. << " nanoseconds" << std::endl;
   11. }

Use the output of this to make a table similar to (these numbers are completely fabricated) the following with the values showing the average of all your runs for this test type:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | 10 | 100 | 500 | 5000 | 25000 |
| Bubble sort | 10 ms | 1000 ms | 25004 ms | 2500312 ms | > 5 minutes |
| Insertion sort | 11 ms | 708 ms | 45646 ms | 98984 ms | 98798797 ms |
| Merge-sort | 50 ms | 652 ms | 44646 ms | Ran out of memory | Ran out of memory |
| Quicksort | 42 ms | 753 ms | 88544 ms | 990090 ms | Ran out of memory |
| Heap-sort | 39 ms | 889 ms | 7557 ms | 80008 ms | 8888889 ms |
| Counting sort | 101 ms | 656 ms | 3355 ms | 99665 ms | 8889898 ms |
| Radix-sort | 512 ms | 1101 ms | 2002 ms | 77757 ms | 7747474 ms |

If any 1 test run takes longer than 5 minutes, you may discontinue that test and record that the time took longer than 5 minutes. Likewise, should any test crash due to running out of memory, record that as well. Graph this data and explain how well or poorly it matches your expectations for performance given the known Big O notation for the given sort algorithms. Include what you expected for time for each of the array sizes based on the results for array size of 10.

1. Create a linked list class that can store Student information. The Student information must include First Name, Last Name, MNumber and may include any other additional information you wish. In addition to any required members to make the linked list work, include 3 of the above sort algorithms to support sorting by First Name, Last Name and MNumber (each algorithm sorts by 1 of the 3) and includes a parameter for ascending or descending. Seed your linked list with data for 50 students that will result in a different order for each of the fields. Include a menu interface that allows the user to select the sort method and direction and will display the sorted students on the screen.

**Submission:**

Submit all source code files and any required data files in a zip file. Include a write up as a PDF including:

* The name of all group members (minimum 2 members, maximum 4 members).
* Instructions for compiling and running the program including any files or folders that must exist.
* What each group member contributed. If the contributions are not equitable, what portion of the grade each group member should receive.
* Table and graph from requirement 2 along with your writeup of the results from that requirement.

Submission should be submitted via Canvas..

**Grading:**

1. 20% - Requirement 1 is completed and working
2. 25% - Code for Requirement 2 is completed and working
3. 15% - Analysis for Requirement 2 explains your results including any unexpected results.
4. 30% - Requirement 3 is completed and working.
5. 10% - Code is well formatted, well commented and follows a reasonable style.

If program fails to compile, the grade will be limited to a max grade of 50%.