CSC 17c C++:Data Structures **Name:** _____
Fall 2023
Final
12/06/23
Time Limit: Maximum of 7 days

The Final contains 3 pages and 6 questions. Total points possible are 100.

Each problem requires a program and some analysis. Scan the analysis by scanner or by phone. Include the analysis for each problem in a separate folder with the corresponding computer project. Create Netbeans projects for each problem. Remove the build and dist folders before zip the final folder. Place all solutions in a folder and submit to canvas.

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1. (15 points) Hashing
   We would like to use initials to locate an individual. For instance, MEL - 635 should locate the person Mark E. Lehr. Note: this is all upper case. Generate a hash function for the above using the numbers on your telephone. You know, each letter has a number associated with it, so examine your telephone keypad. Generate 512 random 3 letter initials and take statistics on a linked list array size 512 to hold this information. Report how many have no elements, 1 element, 2 elements, etc... Also, what is the maximum number of collisions. Do both results agree with the hashing statistics distribution? Show the comparison and analysis?

2. (15 points) Stacks
   Take my hyperbolic sin/cos recursive function place the angle on a sine or cosine stack that represents a call to the sine or cosine. When the program returns, examine the stack for how many times the hyp sine was called and how many times hyp sine/cosine was called vs. the value you were trying to find. Put the results in a table. Range of values from -1 to 1 in .1 radian increments. Does the number of function calls agree with what you predict it should be?

3. (20 points) Queues
   Let us say you are in a line at the grocery store or bank like I was last weekend. One line, yet there are 3 clerks/tellers which service the same line. Simulate the following,

   ```
   Clerk 1 - Services customers on the average 1/min
   Clerk 2 - Services customers on the average 0.5/min
   Clerk 3 - Services customers on the average 0.75/min
   ```

   Customers - Arrive at 4/minute intervals. When the line gets to 5 customers add one more Clerk with the same service rate as Clerk 1. Add one more clerk similarly for each 5 customers. Take tellers away when they have serviced the line according to how they were added. For instance, if a 4th clerk was added to the line because there were 5 customers waiting then remove the clerk when the customer count in line goes to zero. What is my average customer wait time? What is the max number of customers in the line? If you randomize servicing and arrival times by +-50% how does this change the results?

short: the size of the short type is 2 bytes (16 bits) and, accordingly, it allows expressing the range of values equal to 2 to the power 16: 2^16 = 65 536. Since the short type is a signed one, and contains both positive and negative values, the range of values is between -32 768 and 32 767.

4. (15 points) Sorting
   Create a list of 100000 random short integers. Use the merge and selection sorting routines we discussed to choose the top p elements in the list. Let us say for example p is 8. Then show by timing, recording operations and analysis for the Order of each algorithm like you did on the midterm except of course this is a different kind of selection sort. You get to stop after p elements have been sorted. Does the size of p change the analysis and when does 1 sort outperform the other.

5. (15 points) Binary Trees
   Take problem 1 and put each of the 3 letters in a sorted binary tree. Compare number of nodes to identify a match with the hash vs. the tree. Use the AVL technique to balance the tree.

6. (20 points) Weighted Graph
   In the vertex and edge structure defined below

```
Vertex  Edge    Vertex
SFO     2703        BOS
SFO     1847        ORD
ORD      868        BOS
ORD      743        JFK
JFK      189        BOS
SFO     1465        DFW
DFW      803        ORD
DFW     1124        MIA
MIA     1093        JFK
MIA     1257        BOS
SFO      338        LAX
LAX     1234        DFW
LAX     2341        MIA
```

Calculate by hand as well as developing a program as a check.

a) Find the shortest distance between ORD and LAX.

b) Find the shortest distance between JFK and SFO.

c) Find the minimum spanning tree.

From Final - Each problem requires a program and some analysis. Scan the analysis by computer project.

1. Hashing
   Sim -7
   Analysis -8
   Does it compare to Theory?

```
   Max value and distribution.

2. Stacks
   Sim  -7
   Analysis  -8
   Compare table output values to input?
   What do you see and why.  What does
   Theory say about recursions?

3. Queues
   Sim -10
   Analysis  -10
   How does the static compare to the random?
   Why so different?

4. Sorting
   Sim  -7
   Analysis  -8
   What is the new BigO of Selection Sort
   How does this compare to Merge?

5. Binary Trees
   Sim  -7
   Analysis  -8
   How does the compare to Hashing?

6. Weighted Graphs
   Sim  -10
   Hand Analysis  -10
   Does the hand analysis agree with program?
```