CS 692 Algorithms Capstone Exam, Fall 2024.

Please read the following instructions before you start the exam. Please avoid asking a question that is addressed below:

1) You can write your answers **on front AND back sides of the pages**: If you run out of space as you answer the questions on the front pages, just continue your answer on the back of the page. Please do not ask the instructor whether you can write on the back side or not again. The answer is YES YOU CAN.

2) You may use the **last paper** sheet (front and back) as the scratch paper. It is also marked as scratch paper on both sides. Please note that the instructor will NOT grade the scratch paper. The scratch sheet stays with the instructor. Please do not take that apart.

3) Do NOT disjoint the exam sheets. If at any point the papers got disjointed, raise your hand and request for stapling them immediately.

4) You are NOT allowed to have your cell phone, e-watch, or other electronic devices nearby like on the desk or inside your pocket. They should be turned off and stay inside your bag /backpack.

5) You are **NOT** allowed to use Calculator or any other electronic devices. The use of calculators or any other electronic devices during the exam is strictly prohibited. Possessing such devices during the examination will be considered plagiarism and result in a score of zero for the exam.

6) Exam duration: from 3:00 to 4:30 pm.

Please indicate the questions you have completed for grading. If not, we will assume that the first two questions you attempted are to be graded.

☐ Question 1

☐ Question 2

☐ Question 3

Choose any 2 of the 3 problems.
If you answer all three questions, only questions 1 and 2 will be graded.

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Question 1) (20 points)
Count the precise number of "basic operations" executed in the codes below. Your answer should be a function of n ($n \geq 0$) in closed form. Note that "closed form" means that you must resolve all ∑'s, recursive relations, etc. An asymptotic answer (such as one that uses Big-O, Theta, and similar) is **not** acceptable. Show all your work.

Note: You can assume n>=0 in both cases below.

A)

```
for(int i = 1; i <= n; i++)
{
        Perform 1 basic operation;
        for (int j = 1; j <= i; j++)
                Perform 1 basic operation;
         //endfor j
 }//endfor i
```

B)

```
void fun(int n)
{
        Perform 1 basic operation;
        if (n >=1)
        {
                fun (n-1);
        }
}
```

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Question 2) (20 points)
Which of the following six statements correctly describes the relationship between the functions f and g defined in A)-D) below? Note that more than one of the six statements may be correct for each part. You do NOT need to justify your choices.

$f \in \Omega(g)$	$f \in$ little-o(g)	$f \in$ Big-O(g)	$f \in \theta(g)$
	$g \in$ little-o(f)	$g \in$ Big-O (f)	

Please do NOT GUESS: for each incorrect statement -0.5 will be given.

A) $f(n) = 100\, n!$, $g(n) = n^n$

B) $f(n) = 2^n$, $g(n) = n^{100}$

C) $f(n) = n^{(\frac{1}{2})}$, $g(n) = \log_2 n$

D) $f(n) = 2 \log n + 5$, $g(n) = \log n^2 + 1$

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Question 3) (C/C++ coding question) (20 points)

Part a) (10 points)

Write a program that performs the following:

1. **User Input:** An array of integers
2. **Process:** Construct a Binary Search Tree (BST) using the given array.

Requirements:

- Only the **array** data structure should be used for **implementing** and **managing** the Binary Search Tree. Other data structures are not permitted.

Part b) (10 points)

Given the input array my_list = {5, 6, 9, 8, 2, 1}, describe the step-by-step process for constructing a Binary Search Tree (BST) according to the logic you provided in Part (a). Show all your work and explain step by step. Finally, provide a visual representation of the resulting BST.

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Scratch Page- This page (front and back) will not be graded.

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