National University of Computer & Emerging Sciences, Karachi
Fall 2022 CS-Department
Final Examination
21st December 2022, 8:30 AM – 11:30 AM

Course Code: CS2001/AI	**Course Name:** Data Structures
Instructor Name: Dr. Jawwad A Shamsi, Dr. Fahad Sherwani, Ms. Anam Qureshi, Mr. Zain ul Hassan, Mr. Shoaib Rauf, Mr. Shahroz, Ms. Sobia Iftikhar, Ms. Abeer Gauhar, Mr. Ali Fatmi	
Student Roll No:	**Section No:**

Instructions:

- Please return the question paper.
- Please read each question completely before answering it. There are **9 questions and 4 pages**
- In case of any ambiguity, you may make assumption. But your assumption should not contradict any statement in the question paper.
- Show all steps clearly.

Time: 180 minutes. **Max Marks**: 100 points

Question 1 (CLO1)	**(5.5 + 5.5 points)**	**11 points**

Consider the following class:

```
class Book {
private:
        string name;
        int key;                // 0 for DS, 1 for PF and 2 for OOP
        string category;        // DS, OOP, PF
        float price;
public:
        book ();
        book (string pName, string pCat, float pPrice): name(pName), category(pCat), price(pPrice);
        string getCategory()
                { return this.category; }
};
```

Suppose you have an array of books containing **N** no. of elements.

a) Write a function that sorts these books based on their category and arrange them in that array. Your sorting algorithm should have the complexity **O (NlogN)**
void Sort (Book book [], int N);

b) Write a function that searches a book from the array based on name of the book. Your searching algorithm should have the complexity **O (log N)**
void Search (Book book [], int N, string search);

Question 2 (CLO3)	**(11 points)**	**11 points**

The academic department of FAST University holds the batch-wise record of their students. Each record consists of **student_roll_number** and **CGPA**. Note that, roll number as well as CGPA(Assuption: CGPA is unique in this case) cannot be repeated. Your task is to implement a data structure through which a user can get the record of a student with minimum CGPA in constant time. Following is the list of mandatory operations: **insert (), delete (), and getMinCGPA()**

Example:
Student ob = new Student ();

```
ob.insert(1234,2.5);
ob.insert (1435,3.25);
ob.insert(1123,2.75);
ob.getMinCGPA(); // returns 2.5
```

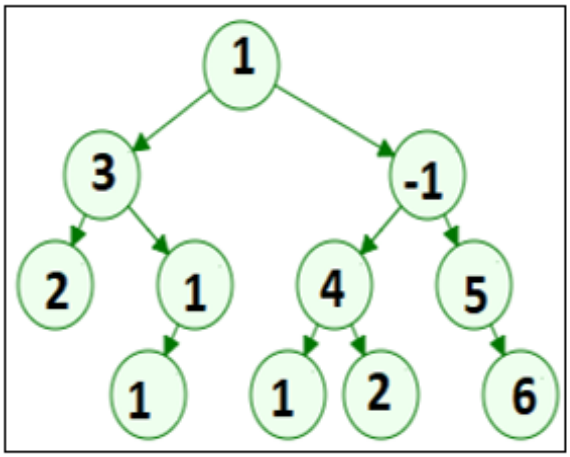
Question 3 (CLO3)	**(5.5 + 5.5 points)**	**11 points**

a) We are inserting **N** nodes into an AVL tree. Will this insertion procedure take O (log n) rotations? Answer with ***Yes*** or ***No*** and briefly justify your answer.
b) We want to insert the keys from the set *{1, 2, 3, 4, 5, 6, 7}* into an initially empty AVL tree. What should be the order of insertion such that we do not have to perform any rotations?

Question 4 (CLO3)	**(11 points)**	**11 points**

Write a function that receives an integer value **k** and reference to root of a binary tree and calculate the number of routes in that binary tree whose sum of node values is equal to **k**. The nodes can also contain negative values. Note that the route does not necessarily have to start with the root.

Example:



Input: n=5
Output: No of paths with sum equals to 5 are: 8
All possible routes equal to 5:
1 3 1
3 2
3 1 1
1 -1 5
4 1
1 -1 4 1
-1 4 2
5

Question 5 (CLO3)	**(2.75 + 2.75 + 2.75 + 2.75 points)**	**11 points**

During holidays or on weekends, a family or an individual typically rents a movie either from a local store or online. Attributes of a movie are as follows: Name of the movie, Name of the director, Name of the production company, Rating, and Number of copies (stock) in the store. Rating is done as follows (1, 2, 3, 4, and 5) [5 being the highest ranking].

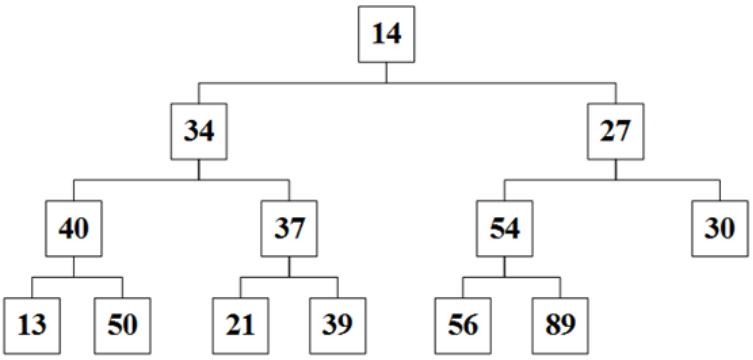
Write a program that does the following:

a) Each node contains details of one movie that are: movie name, director name, production company name, rating, and the number of copies (stock). The movies are sorted by rating.
b) Create a function that returns the number of copies (stock) in the store.
c) Check out (that is, rent) the movie. Search for the particular movie that the user wants to rent [by movie name] and check if the copy is available. Adjust the stock accordingly.
d) Check in (that is, return) the movie. Search for the particular movie that the user wants to return. Increment the number of copies by one, if the video is available.

Use an appropriate data structure to implement the above given scenario. Provide reasoning for your chosen data structure along with the time complexity for each part.

Question 6 (CLO3)	**(11 points)**	**11 points**

An imperfect binary min heap is one that is a valid min heap but only till a certain height. For example, the following imperfect min heap is a valid min heap till its height is **3**.



Write a program that takes reference of root node as parameter and return the height of a valid minheap for the given imperfect binary heap.

Question 7 (CLO2)	**(12 points)**	**12 points**

Given a binary matrix where 0 represents water and 1 represents land, and connected ones form an island, **write a function to count the total number of islands**. For example, the figure given below is a 10X10 binary matrix with total of five islands numbered 1 to 5.

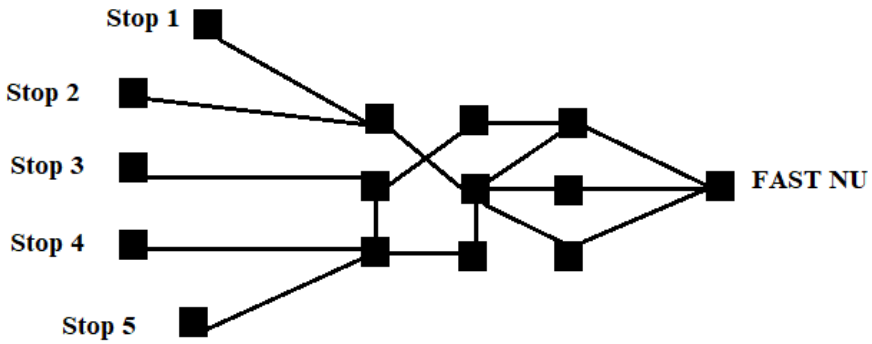
1		2				3	3	3	3
		2		2		3			
2	2	2	2			3			
2			2		3				
2	2	2	2				5	5	5
	2		2			5	5	5	5
					5	5	5		
			4			5	5	5	
4		4		4			5		
4	4	4	4				5	5	5

Question 8 (CLO4)	**(11 points)**	**11 points**

Jadoon Transport provides transport services to FAST-NUCES. It picks students from 40 different starting locations. So, it has 40 different point buses, one for each route. Each route has different locations (stops) on the way to the final destination, which is FAST-NUCES. Devise an algorithm (with pseudocode), which given a starting point covers all the locations of that route in a manner such that the total cost of traversal remains minimal while ensuring that each point bus make a stop at all of its desired locations.

Example:

An illustration of this scenario is presented in the following diagram. Keep in mind that the graph in this problem will be a weighted undirected graph.



Question 9 (CLO3)	**(4 + 4 + 3 points)**	**11 points**

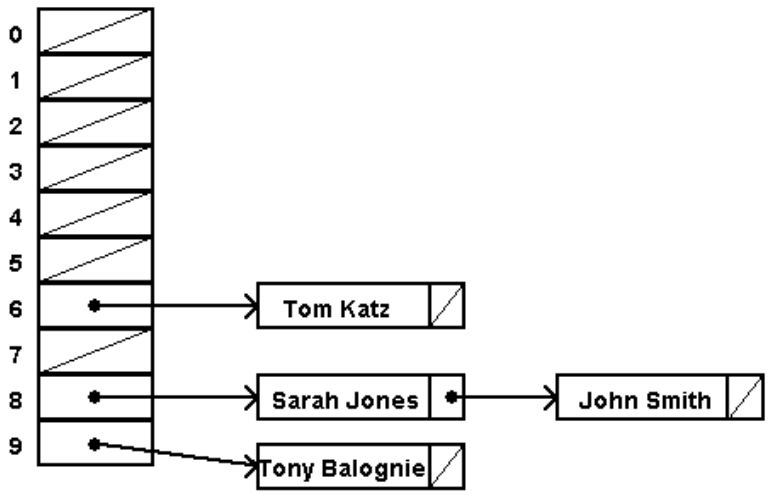
Some FAST-NUCES students want to develop an ASCII code-based dictionary app for their Final Year Project.

This app should allow the users to perform the following operations:

a) **Add_Record ()**
   This function will take a string input from user and add into the dictionary. For adding the string user will use a unique hash function **k MOD 100** *(table size must be 100, for k user will calculate the SUM of ASCII character of that word).*
b) **Word_Search ()**
   User will only pass a single string. If string is not available then generate an error message.
c) **Print_Dictionary ()**
   Users can also display the complete dictionary.

Note: Use Separate Chaining in case of collisions.

Example:



******** Good Luck ********