MAKERERE UNIVERSITY

COCIS, SCHOOL OF COMPUTING & INFORMATICS TECHNOLOGY

END OF SEMESTER I EXAMINATION 2017/2018

PROGRAMME: BSSE/CSC

YEAR OF STUDY: II

COURSE NAME: DATA STRUCTURES AND ALGORITHMS

COURSE CODE: CSC 2100

DATE: Tuesday, 12th December 2017 **TIME: 8:00 -11:00am**

EXAMINATION INSTRUCTIONS

1. **ATTEMPT ALL QUESTIONS IN SECTION A (40 MARKS)**
2. **ATTEMPT THREE (03) QUESTIONS IN SECTION B (60 MARKS)**
3. **DO NOT OPEN THIS EXAM UNTIL YOU ARE TOLD TO DO SO**
4. **ALL ROUGH WORK SHOULD BE IN YOUR ANSWER BOOKLET**

SECTION A (40 MARKS)

QUESTION ONE

(a) Which sorting algorithm is best if the list is already sorted? Why? **(2 Marks)**

(b) What is the complexity of the following code expressed in O( ) notation **(1 Mark)**

```
for (int j = n; j > 0; j--) {
  for (int k = 1; k < j; k = k+k) {
     cout << j+k << " ";
   }
     cout << endl;
}
```

(c) You are given the table below of some sorting algorithms. Establish the time complexity and stability of each algorithm. **(5 Marks)**

Algorithms	**Worst Case**	**Stability**
Selection Sort		
Bubble Sort		
Insertion Sort		
Merge Sort		
Quick Sort		

(d) Explain why hashing is much more preferred to using arrays when accessing data. **(3 Marks)**

(e) What is the number of edges in a complete undirected graph with 6 vertices? **(2 Marks)**

(f) Which data structures are required for the implementation of the following? **(3 Marks)**

(i) Breadth First Traversal on a graph

(ii) Evaluation a postfix expression

(iii)A recursive algorithms

(g) A program T (n) = $(n+1)^2$ has the following running times T (0) = 1, T (1) = 4, T (2) = 9. Prove that $(n + 1)2 \leq 4n2$, deduce whether it is a big-O, big-θ or big-Ω. **(4 Marks)**

QUESTION TWO

(a) Arrays and linked lists are used in the implementation of several data structures. State two the difference between arrays and linked lists. **(4 Marks)**

(b) Draw a binary expression tree that stores the expression: (((a - b) / c) + (d * e)) **(4 Marks)**

(c) The BFS and DFS are the traversal techniques used in traversing a graph. State two differences between BFS and DFS. **(4 Marks)**

(d) Explain why data structure is important in computing? **(2 Marks)**

(e) An algorithm with processing time T(n) = cn^2 spends T(N) seconds for processing N data items. How much time will be spent for processing n = 10,000 data items, assuming that N = 1000 and T(N) = 10ms? **(4Marks)**

(f) What are binary search trees and what is it mainly used for? **(4 Marks)**

(g) Write the two advantage and two disadvantages of separate chaining. **(4 Marks)**

SECTION B (60 MARKS)

QUESTION THREE

The government of Uganda has embarked on a strategy to run internet cables to the following districts;(Pallisa,Budaka)=2,(Pallisa,Kibuku)=4,(Pallisa,Kaliro)=9,(Budaka,Kibuku)=1,(Kibuku,Namutumba)=7,(Kibuku,Bugiri)=7,(Kaliro,Iganga)=2,(Namutumba,Iganga)=5,(Namutumba,Bugiri)=3,(Namutumba,Kaliro)=1,(Budaka,Mbale)=2,(Bugiri,Iganga)=3,(Bugiri,Busia)=1,(Busia,Tororo)=2,(Mbale,Tororo)=10, (Iganga, Jinja)=2, (Jinja, Tororo)=4 where the integer number designates the length of the cable to be connected between districts.

The government with much emphasis tries as much as possible in finding a way to minimize on the length of installing the cables in these districts.

(a) State the data structure suitable for this kind of problem. **(2 Marks)**

(b) Explain with an illustration one of the ways how such a data structure can be implemented. **(5 Marks)**

(c) Write an algorithms that determines the shortest path from Pallisa district to Tororo District. **(5 Marks)**

(d) If the government is to minimize the length of the cables,

(i) State two mechanisms that can be used and in each case write an algorithm to implement these mechanisms. **(4 Marks)**

(ii) Using the algorithms above, implement both mechanisms and show results in each case. **(4 Marks)**

QUESTION FOUR

Sorting is a process that organizes a collection of data into either ascending or descending order. This is done using a number of techniques.

(a) Explain briefly how any 3 of the algorithms used in sorting data works. **(9 Marks**

(b) Given the following sequence 3 9 1 14 24 22 20 17.

(i) Write a partition algorithm that will partition the sequence. **(4 Marks)**

(ii) Sort the sequence using a quicksort algorithm. **(3 Marks)**

(c) Quicksort is claimed to have an expected running time of O(n log n), but it could be as slow as $O(n^2)$.

(i) Briefly explain why Quicksort could use $O(n^2)$ time instead of always running in time O(n log n). **(2 Marks)**

(ii) How can you fix Quicksort so that the expected time is O(n log n), if it can be done? You should give a specific suggestion (don't just say something like "be clever and careful"). Explain why your solution will change the expected time to O(n log n).

(2 Marks)

QUESTION FIVE

Algorithmic is a branch of computer science that consists of designing and analyzing computer algorithms. The design pertains to the description of algorithm at an abstract level by means of a pseudo language, and proof of correctness that, the algorithm solves the given problem in all cases. The analysis deals with performance evaluation (complexity analysis).

(a) State and explain five characteristics of a good algorithm. **(5 Marks)**

(b) Explain the two approaches/method used in the analysis of the algorithm. **(3 Marks)**

(c) Explain three challenges of experimental method of algorithm analysis. **(3 Marks)**

(d) Arrange the following functions in an increasing order of growth rate, showing your working. **(5 Marks)**

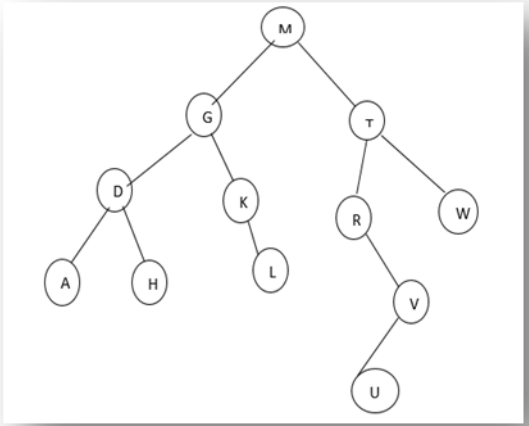
$\left(\frac{3}{2}\right)^n$, 2^{64} - 1, nlog n, n 2^n, n^3 log n, 4^n, log n^3, n^n

(e) A binary search algorithm with a time complexity of O(n log n) spends exactly 5 millisecond to search 10,000 data items. Assuming that time T(n) of searching n items is directly proportional to n log n, that is, T(n) = cn log n, derive a formula for T(n), given the time T(N) for searching N items, and estimate how long this method will search 1,000,000 items. **(4 Marks)**

QUESTION SIX

(a) Give three differences between a tree and a binary tree. **(3 Marks)**

(b) You are given a binary tree below.



(i) Write an algorithm for preorder and postorder traversal **(3 Marks)**

(ii) Determine the preorder, inorder and postorder tree traversal from the binary tree above. **(3 Marks)**

(iii) Implement the above binary tree using an array **(2 Marks)**

(iv) Illustrate how someone can prove that the left and right subtree are children of the parent node in the array in (iii) above. **(3 Marks)**

(c) Make a BST for the following sequence of numbers. 45,32,90,34,68,72,15,24,30,66,11,50,10. **(2 Marks)**

(d) Write an algorithm to insert a node on a binary tree. **(3 Marks)**

QUESTION SEVEN

(a) The Tower of Hanoi is a mathematical game. The game consists of 3 rods, and n disks of different sizes which can slide onto any rod. The puzzle starts with the disks stack in ascending order of size on rod number 1 (the smallest disk is on the top). The objective of the game is to move the entire stack to rod number 3, obeying the following rules:

(i) State the rules of the tower of Hanoi algorithm **(3 Marks)**

(ii) In this problem, please write an algorithm using the recursive technique to output a series of moves which solve the Tower of Hanoi problem. **(5 Marks)**

(b) Write a merge sort recursive algorithm for sorting a given array. **(6 Marks)**

(c) Write a recursive algorithm that implements a factorial of a number n **(6 Marks)**

QUESTION EIGHT

(a) Explain the concept of hashing illustrating how it can be used to form a hash table. **(4 Marks)**

(b) Describe with examples any four hashing techniques used in hash tables. **(12 Marks)**

(c) Collision is one of the problems that any hashing technique cannot avoid.

(i) Under what two circumstances may collision occur in a hash table? **(2 Marks)**

(ii) Describe two ways in which collision may be handled. **(4 Marks)**

WISH YOU MERRY CHRISMAS AND SUCCESS