University of Swaziland
Main Examination

MAY 2010

Title of paper : *Data structures*

Course number : *CS342*

Time Allowed : *Three(3) hours*

Instructions :

- *Each question is worth 20 marks*
- *Answer any five (5) questions*

This paper may not be opened until permission has been granted by the invigilator

Question 1

(a) What is the meaning of the following terms/phrases (2 *marks each*)

(i) abstraction

(ii) data structure

(iii) complexity of an algorithm

(iv) Array mapping function

(v) iterative algorithm

(b) Consider the following record declaration.

```
Var student : Record
                Sid        : Integer;
                Sname      : Array[1..25] of char;
                Age        : Integer;
                TestScore  : Array[1..10] of integer;
              End;
```

Assume each character requires *1 btye* , each integer requires *4 bytes* and and the base address of an student record is 500.

(i) Show a sample student record and how its allocated in RAM. *2 marks*

(ii) What is the base address of each field of the sample student record. *2 marks*

(iii) What is the address of the memory location used to store the value of student.TestScore[3]. *3 marks*

(iv) Using C++ notation, define the structure of a student record. *3 marks*

Question 2

Employee Information System (EIS)

Consider a program that implements Employee Information System for the University of Swaziland as described below:

The program stores and manipulates employee records. For each employee, the tax identity number, firstname, lastname, age, monthly salary and dependents information is stored. For each dependent , the firstname and age are recorded. The program allows the management to perform the following tasks.

- *Add a new employee to its records.*
- *Remove an employee from its records.*
- *Add a new dependent to an employee's record.*
- *Search for a specific employee record given the tax identity number.*
- *Compute the total amount paid to all employees in respect of salaries per month.*

(a) Using C++ notation, write a type definition for a suitable data structure (s) that can be used in the implementation of the Employee Information System (EIS). 12 *marks*

(b) Using the big-oh notation, estimate the running time of each of the tasks that can be performed by management. Justify/Explain your answer. 8 *marks*

Question 3

Construct a 2-3 tree containing the following values:

Masango, Banda, Dube, Cele, Langa, Nkomo, Gule, Khan, Johnson, Zulu, Oyoko, Mamba, Xaba, Musi, Sambo, Zulu, Odumbe, Jele, Gama, Mumba, Hlubi, Hlophe,

Assuming the values are inserted in the order given above. *20 marks*

Question 4

(a) List and describe the operation on a stack data structure. *5 marks*

(b) Using C++, write a linked-list based implementation of a stack including definition of relevant data structures. *15 marks*

Question 5

(a) List and describe the operation on a Queue data structure. *8 marks*

(b) Explain the advantages and disadvantages of each of the following implementation of a queue:

(i) Simple Array-based implementation. *4 marks*

(ii) Circular Linked-list implementation. *4 marks*

(c) Write a pseudocode of an algorithm that multiplies each item in a queue of numbers by 2. Assuming a simple array-based implementation, what is the running time of this algorithm? *4 marks*

Question 6

(a) Draw a graph G containing at least 6 nodes and 7 edges. *5 marks*

(b) Show the adjacency matrix representation of the graph in G above. *4 marks*

(c) Show the adjacency list representation of the above graph G. *4 marks*

(d) Trace the execution of the Depth-First Search (DFS) algorithm on the graph. Assume adjacent nodes are visited in alphabetic order. *7 marks*

Question 7

(a) Draw a binary tree consisting at least 15 nodes and height of 5. The nodes must be labeled 1,2, .., 15 in order of their pre-order traversal. *4 marks*

(b) Write the pseudocode for the post-order traversal for binary trees. What would be the output if the algorithm were applied to the tree obtained in (a) above. *4 marks*

(c) Using C++ notation

(i) Write a suitable definition of a node in a binary tree. *3 marks*

(ii) Write a suitable definition for a binary tree T. *2 marks*

(iii) Define a function to create and initialize an empty tree. What is the running time of the function? *3 marks*

(iv) Define a function to insert a new element into a binary tree T. What is the running time of the function? *4 marks*