University of Kwazulu Natal

School of Electrical, Electronic & Computer Engineering

Examination: November 2013

Data Structures and Algorithms (ENEL2DS H2)

DURATION :	**2 Hours**		Total Marks:	**100**
Examiners :	Internal	:	Mr. C Chibaya	
	Internal	:	Mr. Bhero	

General Instructions:

1. The paper consists of **FIVE** questions. Answer **ALL** questions.
2. The paper carries a total of **100** marks.
3. This is not an open book exam and no notes may be used.
4. Scientific calculators may be used with all program memory cleared.

Question 1 : Basics and Recursion **[20 marks]**

(a) The concept of a variable is key in computer programming, data structures, and algorithms. What is a variable? [1]

(b) Designing programs requires us to use standard tools. Name any three program designing tools that you know of. [3]

(c) When we write C programs, when or why do we include the following header files?

(i) conio.h [1]

(ii) stdlib.h [1]

(d) (i) What is recursion? [2]

(ii) Give one key advantage and one disadvantage of using recursive functions over other iterative looping constructs [2]

(iii) Assuming the values of the three parameters of a function called Oneal ( ) are initially as follows: *victor =7, shaun= 0.0001, and colin=16.* Present a trace table which shows the values that are held in each parameter after every iteration until the base case is reached.

```
double Oneal (double victor, double shaun, int colin)
{
        if (abs(victor * victor – colin) < shaun)
                return victor;
        else
        {
                victor = (victor + colin / victor) /2;
                return Oneal (victor, shaun, colin)
        }
}
```

[5]

(iv) The power of a number a^n, can be expressed as the recursive base case: $a^n = 1$ when $n = 0$. Otherwise, the same power can be expressed as: $a^n = a * a^{n-1}$. Code a C recursive function called *power (int a, int n)* which accepts two integer parameters, a and n, and return the a^n. [5]

Question 2 Mixed questions **[20 marks]**

(a) (i) What is an array? [1]

(ii) When do we say an array is bi-dimensional? [2]

(iii) Code a C function which populates a bi-dimensional array of four rows and three columns with random integers between 10 and 20. [4]

(b) (i) What mainly characterizes a stack? [1]

(ii) Assuming that a stack already exists and is populated with nodes containing people's ages and names. Show how the nodes of this stack are defined, and perform a selection sort of the stack by names. The names should be shown in ascending order when they are displayed on the screen. [7]

(c) (i) Queues implement the First In First Out principle. What would you consider to be the main disadvantage of using a queue over using stacks ? [1]

(ii) A function that sequentially searches for a particular node in a queue uses one pointer other than the head pointer. However the sequential search algorithm has one major disadvantage over the binary search version. Give the disadvantage of the sequential search algorithm when it is implemented on a queue [1]

(iii) Assuming that a queue already exists and is populated with nodes containing people's ages and names. Implement a sequential search function to check if "Shaun" is in the queue. The function should return a 1 if the node is found, or a 0 otherwise. [3]

Question 3: Operations on arrays **[20 marks]**

(a) Assuming that an array of twenty random integers has been created and the following values were generated:

12 15 10 11 18 8 12 5 9 19 23 6 17 7 9 15 22 13 16 5

(i) What is the one condition we have to satisfy before we use the binary search algorithm to search for any desired integer in this array? [1]

(ii) Describe the steps involved in performing a shell sort on this array structure. [5]

(iii) Present a pseudocode which performs a Binary Search for any chosen number in this array assuming that the condition sought in part (i) above has been met. [6]

(iv) Present a trace table which indicates the value that would be pointed at by the mid-point, the lower bound, and the upper bound variables when the binary search algorithm is used to search for a 4 in the array given above. [5]

(b) What would you consider to be the two main advantages and one disadvantage of using arrays over linked lists? [3]

Question 4: Operations on double linked lists **[20 marks]**

(a) Assuming that a double linked list of twenty random integers has been created and the following values were generated:

12 15 10 11 18 8 12 5 9 19 23 6 17 7 9 15 22 13 16 5

(i) What would you consider as the main disadvantage of linked lists over arrays? [1]

(ii) Identify and explain one main purpose of each of the four pointers that are required in the implementation of this list [4]

(b) Describe the steps involved in inserting a desired node at a specified position in this double linked list. [6]

(c) Deleting a node at the end or beginning of double linked lists are the easiest operations. Give a set of codes you require to delete the first and last nodes of double linked lists. [4]

(d) In your own words, describe how one can perform a binary search on a double linked list [5]

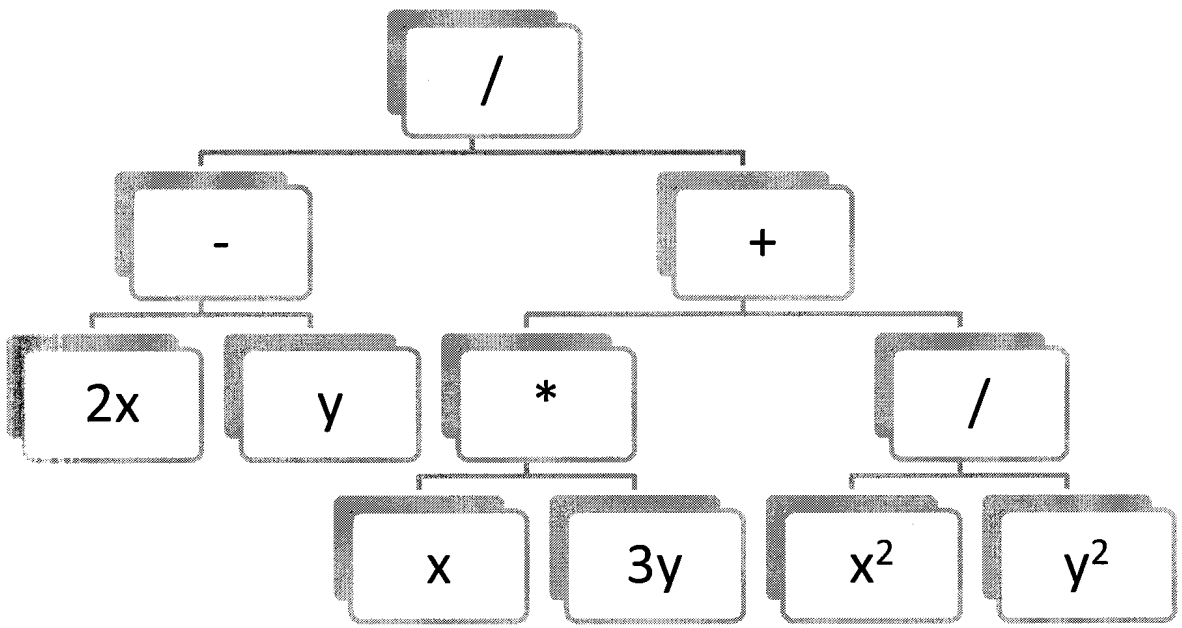
Question 5: Binary Search Trees **[20 marks]**

(a) A binary search tree is required which captures a set of integers such that every integer that is smaller than its immediate root is stored on the left branch of the root, while those integers that are bigger than their immediate roots are stored on the right sub-tree.

(i) Define the struct which can store the node of this tree [1]

(ii) Code a method called *getNode ()* which creates and populates the Binary Search Tree node described above. [3]

(iii) An important method in Binary Search Trees is the one for inserting nodes into the tree. Design a pseudo-code which depicts how nodes are inserted into the Binary Search Tree describe above. [6]



(b) Traversing binary trees is classified by the order in which the nodes are visited. There are three ways of traversing binary search tree nodes namely preorder, inorder, and postorder. Below is a binary tree representation. Represent this binary tree as an algebraic expression that has been traversed using:

(i) Postorder access [2]

(ii) preorder access [2]

(iii) inorder access [2]

(c) Provide the codes for traversing a binary search tree using the preorder and post order methods [4]