University of KwaZulu Natal

School of Electrical, Electronics & Computer Engineering

November Main Examination 2015

Data Structures and Algorithms (ENEL2DS H2)

Duration : 2 hours Total marks : 100

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General instructions

1. The paper consists of 6 questions. Answer **ALL** questions.
2. The paper carries a total of 100 marks
3. This is not an open book examination and no notes may be used.
4. Scientific calculators may be used with all program memory cleared

Question 1 — 10 Marks

(a) As proof of your understanding of the basic programming constructs used in C:

(i) Draw a trace table to indicate the values taken by each of the variables and the output of the following program segment.

```
int a=1, b = 1, c;
printf ("%d", a);
for (int  i = 2; i < 10; i ++)
{
        c = a + b;
        a=b;
        b= c;
        printf ("%d", a);
}
```

[4]

(ii) From your trace table, what does the above program segment determine? [2]

(b) There are two other looping constructs other than the FOR statement and the use of recursive functions. Identify these two other looping statements and indicate their unique features and properties. [4]

Question 2 — 15 Marks

(a) What is a recursive function? [1]

(b) A recursive function is mathematically defined as follows

$$s(c, v) = \begin{pmatrix} c & when\ v = 0 \\ s(v, c\%v) & otherwise \end{pmatrix}$$

(i) Draw up a stack to find *s (c,v)* when c is initially 56 and v is initially 21. [4]

(ii) Write *C* codes to define this recursive function [4]

(iii) Mathematically what does the function do? [1]

(c) Draw a trace table to show the values in each variable when the following recursive function is executed. The initial values of variables; *s, c, v* and *m,* are 18, 1, 1 and 1 respectively?

```
int nov (int s)
{
    if (s!=0)
    {    c = s % 2;
         v = c + c * m;
         m =m * 10;
         nov ((int) s / 2);
     }
    return v;
}
```

[5]

Question 3 — 15 Marks

(a) In what does an array differ from a normal variable? [2]

(b) Show the updated order of values in the following array of integers after the first and second passes when each of the following algorithms is used. The question requires you to only give the updated order of values after each complete pass.

(i) use the shell sort algorithm to sort the array below in ascending order [4]

(ii) use the bubble sort algorithm to sort the array below in descending order

19 8 13 17 3 8 15 6 [4]

(c) Assuming that the array described in (b) above has been created and sorted in ascending order. Code a *C* function called *binSearch ( )* which accepts two parameters; an integer parameter called *element* which holds the value to be searched for, and an array parameter called *data* which stores the integer values listed above. The function *binSearch* () searches for *element* from *data* using the binary search method and conditionally returns a message "*found*" or "*not found*". [5]

Question 4 — 20 Marks

(a) Using a diagram (labelled using the key pointers), visualize the representation of a stack and a queue. In each case, give an acronym which distinguishes each data structure from the other. [4]

(b) Assuming nodes comprising of usernames, passwords, and some integer value (between 0 and 3) representing the user's priority level:

(i) Write C codes to define a queue node and three pointers required to create a queue. [4]

(ii) Code a void function with which to create a queue of ten user nodes. Your program validates the priority level before recording it the priority field. [6]

(c) If you are told that priority levels of 0 indicate unauthorized users. Write C codes to delete (from the queue defined in (b) above) all nodes in which the priority level is 0. [6]

Question 5 — 20 Marks

(a) Double linked lists are more useful than stacks and queues. In what does a double linked list differ from stacks and queues? [2]

(b) Describe the purposes of the three main pointers required when creating a double linked list [3]

(c) Assuming nodes comprising of usernames, passwords, and an integer representing the user's priority level (between 0 and 3), and assuming that a double linked list has been created/populated:

(i) Write codes to delete the nodes of unauthorized users (those whose priority level is 0) [4]

(ii) Sort the double linked list in ascending order of usernames using selection sort. [5]

(iii) A new node is required after sorting the double linked list as described in (ii) above. Insert a new node at an appropriate position in the sorted double linked list. [6]

Question 6 — 20 Marks

(a) What is the key rule one must observe when creating binary search trees? [1]

(b) The following are elements of a binary search tree. Draw a binary tree diagram to store these values observing the rule referred to in (a) above : 17, 45, 31, 15, 4, 6, 11, 60, 16, 3, 20, 35 [3]

(c) Provide C codes to:

(i) Define a binary tree node which would hold the values given in (b) above. [2]

(ii) Create a binary tree to store the 12 values above. Suppose these 12 values are currently stored in an array called treeVal. [5]

(d) Values in a binary tree can be traversed in three different ways.

(i) Write C codes for traversing the above described binary tree using each approach [6]

(ii) What would be the output of the binary tree when each approach is used? [3]

END OF EXAMINATION