THE OPEN UNIVERSITY OF SRI LANKA
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

FINAL EXAMINATION 2009
DIPLOMA IN TECHNOLOGY – LEVEL 4

ECX4235 – DATA STRUCTURES AND ALGORITHMS

DATE: MARCH 23, 2010 **TIME: 1400-1700 HRS**

This question paper consists of Part A and Part B. You are to answer altogether
5 questions including the question in Part A. All questions carry equal marks.

If necessary you may refer the annexure for writing pseudo codes.

PART A (Compulsory) (20 Marks)

1. There are two sets of numbers represented in unordered singly linked lists named
   S and T. Each set consists of distinct numbers.

   You are to determine whether S=T, that is S consists of all the numbers in T and
   only that.

   Pointers to the first nodes of two lists are given to you. Lengths of lists are
   unknown to you.

   To perform the above task in a minimum time complexity, you are expected to
   proceed as follows:

   i.   Check whether both sets are of the same size. If they are not, they can not
        be equal. Assume S has s elements and T has t elements. If $s \neq t$ then $S \neq T$.

   ii. If both lists are equal in size, then elements in each list are to be checked
        whether they are same. To do that,

        a. First, create a hash table of size s with chaining and iterate over S,
            adding each element from S to the hash table. You may assume the
            hash function as h.

        b. Then, search whether each element in T is also present in the hash
            table. If any item is not in the hash table, then $S \neq T$.

   iii. If S=T, the algorithm should return *true*.

   1.1 You are to present your algorithm in pseudo codes for the solution proposed
       above.

   For clarity, you may break your solution into number of subroutines to perform
   tasks mentioned in i and ii. You should clearly specify the purpose of each
   subroutine. Further, iterative statements should be represented as loops. Write
   descriptive comments wherever necessary.

   1.2 Calculate the worst case time complexity of your solution.

PART B (80 Marks)

2.

2.1 You are to propose an appropriate sorting algorithm to sort an array for each of the following situations. List the sorting algorithm you propose along with the worst case time complexity and the space complexity.

    i. The array consists of two separate sorted subsets, one following the other

    ii. The array has only one or two elements out of place

    iii. The range of elements in the array is known to you and it is very small when compared to the number of elements in the array.

<div align="right">[6 Marks]</div>

2.2 Briefly describe the purpose of having a base case and the recursive case in a recursive subroutine.

<div align="right">[4 Marks]</div>

2.3 Write pseudo codes for an iterative subroutine to check whether a given word or a sentence is a *palindrome*. A *palindrome* is a word or a sentence that can be read the same way in either direction (*'Never odd or even'* is a palindrome). Your algorithm should ignore the spaces in the middle of the sentence (if any). It should return, true, if a palindrome, false, if not a palindrome. Assume the word or the sentence is given in an array consisting of each letter as an element and the size of the array is given to you.

<div align="right">[10 Marks]</div>

3.

3.1 Briefly describe the significance of two factors considered in algorithm analysis.

<div align="right">[4 Marks]</div>

3.2 Write a pseudo code subroutine to append the two circular lists shown in figure 1 to make a single circular list as shown in figure 2.
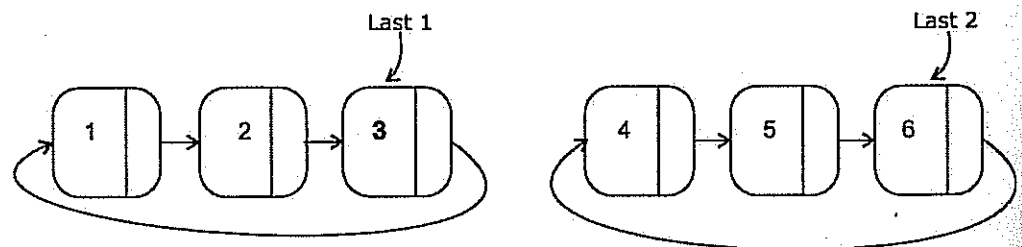
Figure 1: **Before** appending two lists
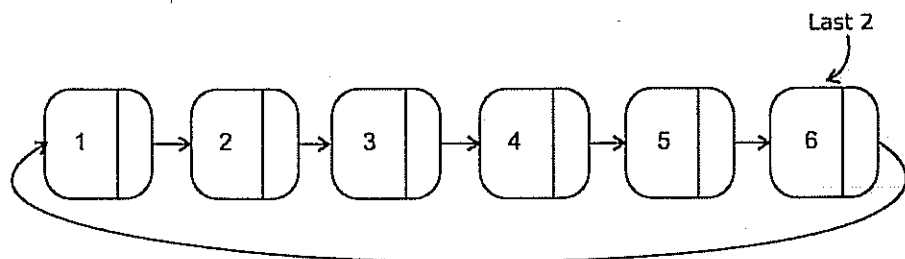
Figure2: **After** appending two lists

<div align="right">[10 Marks]</div>

3.3 Write a recursive subroutine to count the total number of nodes having only a single child node in a given binary search tree. Input parameter to the subroutine is the root of the tree. The subroutine should return the total number of nodes satisfying the above condition as an integer.

[6 Marks]

4.

4.1 List the rules to be followed while inserting or deleting items of a red-black tree.

[4 Marks]

4.2 Write a pseudo code subroutine to sort a singly linked list using bubble sort.

[8 Marks]

4.3 Write a pseudo code subroutine to insert a new node to somewhere in the middle of an ordered linked list while maintaining the sorted order. State your assumptions.

[8 Marks]

5.

5.1 List the *breadth first* and *depth first* search sequences for the following graph (figure 3). Assume the search starts at node 'a'.
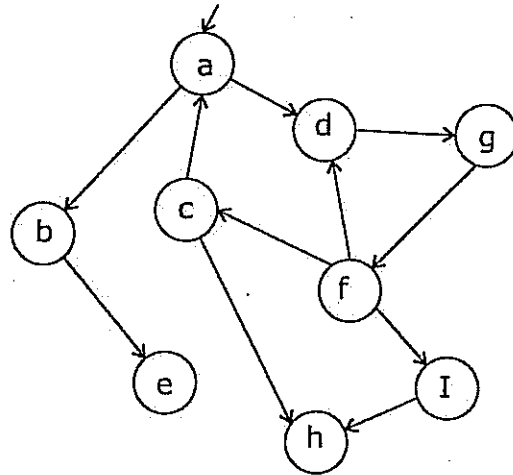

Figure 3

[8 Marks]

5.2 Following description is about the people and initial tasks involved in the departmental level in designing a new degree programme at a University. You are to model the scenario using object oriented (OO) techniques.

The overall responsibility of the process is assigned to the Programme Chair who is a Senior Lecturer from the department. Programme Coordinator is the person suppose to coordinate the entire process between different stakeholders of the process.

In order to make the students more employable, new study programmes are initiated in collaboration with professional bodies from the respective industry.

Professional bodies can be considered as a collective of companies servicing in the respective sector.

Curricular of the degree programme is designed by the programme development team which comprise of academic staff members form the department and the representatives from the professional bodies. Programme development team is lead by the Program Chair. Curricular of each course is designed by a course team. Each course team consist of members from the internal academic staff and members from the industry. Some course teams comprise of academic staff members from other universities as well. Each course team is lead by a course team chair who is a Senior Lecturer of the department.

Preparing lesson materials and the activities for courses is done by the respective course teams. Each course comprises of several Units of lessons. Each unit comprises of several study sessions. Each study session is written by a session author. Each session is reviewed by one or more reviewers and has to be approved by the course team. Each course consists of continuous assessment activities – TMAs, CATs, MPs and/or Case Studies- as well as a final examination.

i.   Identify the classes and the objects in the above scenario.

[4 Marks]

ii. Draw a class diagram showing associations and inheritance relationships.

[8 Marks]

6.

6.1 List three advantages of static data structures over dynamic data structures.

[3 Marks]

6.2 Distinguish the heap data structure from the binary tree data structure.

[4 Marks]

6.3 Draw the tree representation of the following heap after inserting 19 to the heap.
     25, 21, 18, 16, 14, 15, 13, 8

[6 Marks]

6.4 You are given the subroutines to insert an item a to the heap, hInsert(a), and the subroutine to remove (and return) an item from the heap, hRemove. Using the given subroutines, write pseudo codes for heap sort.

[7 Marks]

7.

7.1 Write the sequence of nodes if the following tree (figure 4) is traversed in in-order, pre-order and post-order.
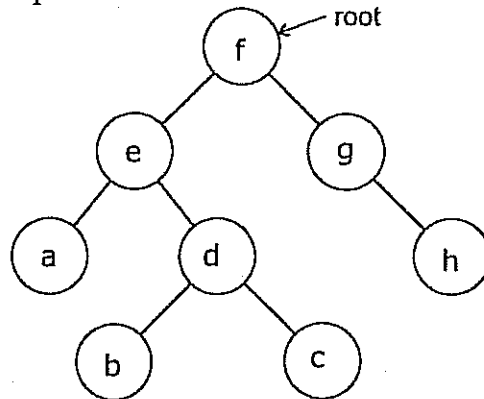

Figure 4

[8 Marks]

7.2 Function $f(x)$ has a root in between the x coordinates x_0 and x_1 as shown in the figure 5.
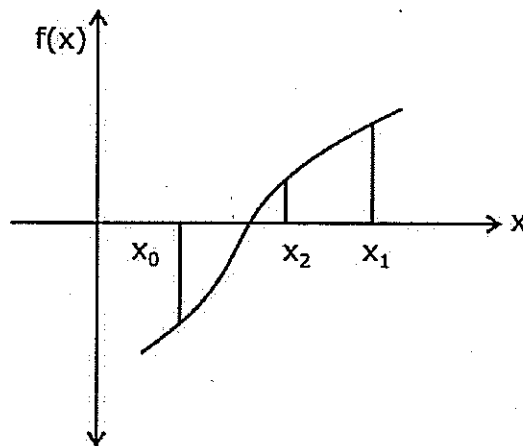

Figure 5

You are to apply *successive bisection method* which is explained below to find the root. This method begins the iterative cycle by picking two trial points, x_0 and x_1, which enclose the root. Two points x_0 and x_1 enclose a root only if $f(x_0)$ and $f(x_1)$ are of opposite signs. First the interval (x_0, x_1) is bisected in order to find the mid point, x_2. So that $x_2 = (x_1 + x_0)/2$. If $f(x_2) = 0$ then the root is found.

However, if $f(x_2) > 0$, then the root is between x_0 and x_2. Therefore we replace x_1 by x_2 and bisect. If $f(x_2) < 0$, then the root lies between x_2 and x_1. Next, x_0 is replaced by x_2 and bisect. This way the search interval is halved in each iteration. This has to be repeated until the root is found or the search interval becomes smaller than the expected precision of the answer. In this case you may assume that the expected precision as P.

i. Write a pseudo code algorithm to find the root.

[10 Marks]

ii. If x_0 or x_1 is a root of the function, calculate the number of iterations of your algorithm.

[2 Marks]

Annexure:
Pseudo code convention

This is based on the pseudo *code convention* that you received as a supplementary document in this course. Therefore, you may continue writing pseudo codes as you were trained in the course. Only a set of frequently used statements are shown below.

OPERATORS

Assignment:
Variable=expression

Arithmetic:
( ), -, *, / , +, -

Comparison:
=, < >, <, ≤ , >, ≥

Logical:
not, and, or

IF-THEN-ELSE

```
IF condition THEN
        Sequence 1
ELSE
        Sequence 2
ENDIF
```

WHILE

```
WHILE condition
        Sequence
END WHILE
```

CASE

```
CASE expression OF
        Condition 1: sequence 1
        Condition 2: sequence 2
        ...
        Condition n: sequence n
OTHERS:
        Default sequence
END CASE
```

FOR

```
FOR condition
        Sequence
END FOR
```

INVOKING SUB PROCEDURES

A sub procedure can be invoked in the middle of the program by using CALL keyword.

DECSCRIPTIVE COMMENTS

Comments can be written by using "/" at the beginning of the line
        /this is a comment

SAMPLE PSEUDOCODE

Following sample shows how it looks like when you build an algorithm using Pseudo code.

```
Subroutine FindABC

p,q,r and k are integers
X is a sorted integer array

Begin
    p=0,
    q= X.length -2
    r= X.length -1
    k= X.length -1

    While (k <= 2)

        While (p<q)
                If X[p]²+X[q]² = X[r]² then return true

                If X[p]²+X[q]² < X[r]²
                        Then    p=p+1
                        Else    q=q-1
                    End if
        End While
        K=k-1
            P=0
            R=r-1
            Q=r-1
    End while
End

End FindABC
```