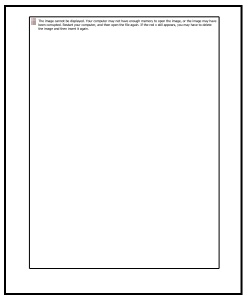

University of Moratuwa, Sri Lanka

Faculty of Engineering

Department of Computer Science and Engineering

B.Sc. In Engineering

Level 2 – Semester 2 Examination

CS 2020 – Data Structures and Algorithms

Time Allowed : **Two (2) Hours** June 2009

Instructions to candidates

- This paper consists of four (4) questions
- Answer ALL FOUR (4) questions.
- Use **separate answer books** to answer SECTION - A and SECTION - B
- All questions carry equal marks
- This is a **closed-book examination**
- This examination accounts for 70% of the course module assessment

SECTION – A

Question 01 (25 marks)

(a) Answer the following questions based on your knowledge on dictionaries and hash tables.

(i) List an advantage and a disadvantage of the dictionary data structure. [2 marks]

(ii) Explain how the disadvantage mentioned in part (i) has been overcome in hash tables. [1 mark]

(iii) Explain how a hash table can be implemented combining the features of a static array and a linked list. [3 marks]

(iv) Name one disadvantage of using a static array for implementing a hash table as mentioned in part (iii). [1 mark]

(v) Explain how the disadvantage mentioned in part (iv) can be overcome. [1 mark]

(b) Write the list of nodes in the order visited in the post-order, pre-order and in-order traversals for the tree given in figure Q1. [6 marks]

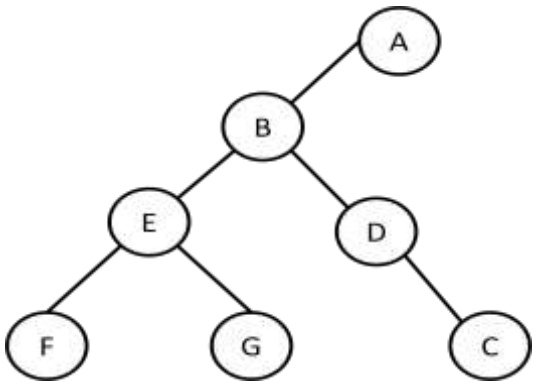

Figure Q1

(c) In a tree, the Least Common Ancestor (LCA) of two nodes X and Y is a node Z that is the ancestor of both X and Y that is furthest from the root of the tree.

(i) In the tree given figure Q1, what is the least common ancestor of nodes G and C? [1 mark]

(ii) You are required to write a function GETLCA(BINARYTREE BT, NODE A, NODE B) in pseudo code, that takes in a simple binary tree, and two tree nodes A and B as input, and returns the least common ancestor of A and B.

(A) Draw and label the structure of the tree node that you will be using when implementing the above function [2 marks]

(B) Write the function GETLCA(BINARYTREE BT, NODE A, NODE B) in pseudo code. [5 marks]

(C) Evaluate the running time of the function GETLCA(BINARYTREE BT, NODE A, NODE B). [3 marks]

Question 02 (25 marks)

(a) Answer the following questions based on your knowledge on minimum spanning trees.

(i) What is a minimum spanning tree? [1 mark]
(ii) Name two algorithms used for finding the minimum spanning tree. [2 marks]
(iii) On which algorithm design technique are the two algorithms mentioned in part (ii) based on? [1 mark]
(iv) What is the main difference between these two algorithms? [2 marks]
(v) Name two applications of minimum spanning trees. [2 marks]

(b) Answer the following questions based on your knowledge on stacks.

(i) Determine whether the {} [] and () symbols are balanced in the following expression by using a stack. Note down all the intermediate steps. [3 marks]

({[5+6] – 1) + 2*8}

(ii) A sequence of intermixed ten push and ten pop operations are performed on a stack. The integers 0 through 9 are pushed on to the stack in ascending order. After each push operation the returned value is printed on screen. Explain whether the following sequences of integers can or cannot be printed on the screen as a result. [3 marks]

(A) 4 3 2 1 0 9 8 7 6 5
(B) 0 4 6 5 3 8 1 7 2 9
(C) 1 4 7 9 8 6 5 3 0 2

(c)

(i) You are required to write a function **MOVENODE(LIST 1, LIST 2)** that takes two lists as input, removes the front node from the second list and inserts it onto the front of the first.

(A) Draw and label the structure of the List that you will be using when implementing the above function. [2 marks]
(B) Write the function MOVENODE(LIST 1, LIST 2) in pseudo code. [4 marks]

(ii) You are required to write a function **SORTEDMERGE**(**LIST 1, LIST 2**) that takes as input two lists, each of which is sorted in increasing order, and merges and returns the two together into one list which is in increasing order. You can make use of the function **MOVENODE(LIST 1, LIST 2)** which you have implemented in part (i). [5 marks]

SECTION B

Question 03 (25 marks)

(a) Answer the following questions based on your knowledge on searching.

(i) What is the major advantage of binary search over linear search? [1 mark]

(ii) What precondition must hold true for binary search to work? [1 mark]

(iii) What is the property that makes a binary tree a binary search tree (BST) ? [2 marks]

(iv) Draw the resultant BST after the numbers 4, 14, 7, 2, 8, 1 are inserted to an initially empty BST. [3 marks]

(v) Show the steps in deletion of the node with the value 4 in the BST obtained in part (iv). [3 marks]

(b) Sort the following array of integers, showing all intermediate steps, using Merge sort and Quick sort algorithms. [6 marks]

2	41	52	26	38	57	9	49

(c) The height and weight of n students are measured and recorded in two finite arrays of integers. Let $A = \{a_1, a_2, \dots, a_n\}$ represent the heights while $B = \{b_1, b_2, \dots, b_n\}$ represent the weights of the students.

(i) Consider the following Bubble Sort algorithm.

INPUT: an array of integers $X = \{x_1, x_2, \dots, x_n\}$

OUTPUT: sorted array $X' = \{x'_1, x'_2, \dots, x'_n\}$

such that $x'_1 \leq x'_2 \leq \cdots \leq x'_n$

1. $for\ i \leftarrow length[X]\ to\ 1$
2. $\quad do\ for\ j \leftarrow 1\ to\ i-1$
3. $\quad\quad do\ if\ X[j] > X[j+1]$
4. $\quad\quad\quad then\ \boldsymbol{exchange}\ X[j] \leftrightarrow X[j+1]$

Modify the given algorithm to sort the students by their heights and then by weights. i.e. if two students have the same height then the one with the lower weight should take the precedence over the other. For example, when the arrays $A = \{6, 5, 4, 5\}$ and $B = \{60, 65, 55, 40\}$ are given as input, then the output will be the arrays $A' = \{4, 5, 5, 6\}$ and $B' = \{55, 40, 65, 60\}$. [5 marks]

(ii) Show steps of sorting when the following two arrays are given as input to your algorithm.

$$A = \{22, 23, 21, 20, 22, 23, 25, 27\} \text{ and } B = \{50, 55, 49, 45, 58, 39, 42, 34\}$$

Note: You need to show steps only until sorting is completed. [4 marks]

Question 04 (25 marks)

a) Consider the Fibonacci number series defined by F(n) as follows.

$$F(n) = \begin{pmatrix} 0 & n = 0 \\ 1 & n = 1 \\ F(n-1) + F(n-2) & n \geq 1 \end{pmatrix}$$

(i) Draw a recursion tree to find F(5). [2 marks]

(ii) What is the disadvantage of the above approach? [1 mark]

(iii) Show how a bottom-up approach with recording results can be used to calculate F(5). [3 marks]

(iv) Briefly explain the meaning of optimal substructure property and overlapping sub problems in Dynamic Programming. [2 marks]

(v) What is the property common to both Greedy Approach and Dynamic Programming? [1 mark]

(vi) What is the major difference between Dynamic Programming and Divide-and-Conquer approach? [1 mark]

b) State whether the following statements are true or false. If a statement is false justify your answer briefly.

(i) Algorithms measure the reusability of software systems and reusability is the most important feature of software systems. [2 marks]

(ii) The running time of a particular algorithm is used as a measure of its efficiency and we are more concerned about the growth of the running time than the running time itself. [2 marks]

(iii) In general lower bounds are preferred than upper bounds in asymptotic analysis of algorithms [2 marks]

c) The following recurrences express the running times of three recursive algorithms. For each case, solve the recurrence using the Master Method and give the complexity of the algorithm. If in a particular case it cannot be done using the Master Method, explain why.

(i) $T(n) = 7T\left(\frac{2n}{4}\right) + n^2$ [3 marks]

(ii) $T(n) = 3T\left(\frac{7n}{5}\right) + n^2$ [3 marks]

(iii) $T(n) = 9T\left(\frac{n}{3}\right) + n^3$ [3 marks]