University of Moratuwa, Sri Lanka

Faculty of Engineering

Department of Computer Science and Engineering

B.Sc. In Engineering

Level 2 – Semester 2 Examination

CS 202 – Data Structures and Algorithms

Time Allowed : **Two (2) Hours**   April 2008

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) Selecting an appropriate Data Structure for a given situation provides considerable performance improvements. Do you agree? Explain your answer with an example.

[3 marks]

(b) Binary Tree is a data structure that facilitates performance improvements for some applications.

(i) What is a Binary Tree? [1 mark]

(ii) Binary Search Tree is a variant of a Binary Tree with an important property. What is a binary Search Tree? What is the important property that identifies a Binary Search Tree?

[3 marks]

(iii) Insert the following numbers to a Binary Search Tree and draw the resulting Binary Search Tree.
            16, 10, 204, 100, 55, 22, 40

[4 marks]

(iv) Traverse the tree in
    a. Inorder
    b. Preorder
 and write the sequence of nodes visited [4 marks]

(v) Sunil and Kamal are Level 2 students taking the Data Structures and Algorithms Lessons. For an assignment under Data Structures they have implemented a binary search tree with following methods:
    • Inserting numbers in to the tree
    • Deleting a given number from the tree
    • The Preorder Traversal of the tree.
 Now they are learning Sorting methods. The next assignment for them is to sort a given set of integer numbers in ascending order. Kamal says he is going to write a new program for the sorting assignment but Sunil believes that he can use the Binary Search Tree Program he has written with modifications to sort the set of numbers. How can Sunil change his previous assignment to accomplish the goal of sorting a set of integers? Explain your answer   .

[6 marks]

(c) English is a language made up of 26 letters. These letters make up words. Suppose you are to build a dictionary with a given set of words (1000 words) and you should be able to search whether the spellings are correct. If there is a spelling mistake you should be able to provide the possible words.
Describe the data structures you would use in solving this problem. You should explain clearly and can use diagrams to illustrate your answer. [4 marks]

Question 02 (25 marks)

"Calculating factorial of a given number can be achieved using recursion".

(a) (i) What is recursion? Show how you can calculate factorial using a recursive function.

[2 marks]

(ii) What is the data structure used to perform recursions?   [2 marks]

(b) The diagram below represents the adjacency matrix of a graph.

	0	1	2	3	4	5
0	0	1	0	1	0	0
1	0	0	1	1	0	0
2	1	0	0	1	0	0
3	1	1	1	0	0	1
4	0	0	0	0	0	0
5	0	0	0	0	1	0

(i) Draw the graph represented by this adjacency matrix.   [4 marks]

(ii) Represent this graph using the adjacency list representation.   [4 marks]

(c) The diagram below (Figure 1) shows the retail outlets of a super market chain. The company owns one warehouse and from this warehouse the goods are transported to the retail outlets. Some of the roads in the area are one -way routes (arrow heads show the direction of traffic allowed). Show step by step workings in obtaining the answer identifying shortest path from warehouse to each retail outlet using the Dijkstra's Algorithm. Find the minimum distance that the lorry needs to travel from the warehouse to each retail outlet to deliver goods. State any assumptions you make.
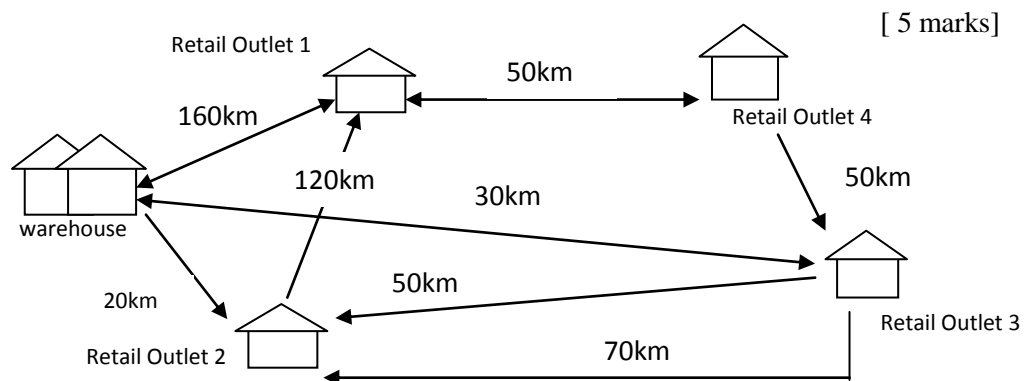
[5 marks]

Figure 1

(d) Suppose all the Roads shown in Figure 1 were two way roads. (no restrictions making the roads one way) You are supposed to connect the warehouse and the retail outlets by a network to enable better communication facilities.

(i) What is the minimum length of wires you would require to make the connections? You need to show the step by step workings how you arrived at your answer.

[6 marks]

(ii) What is the algorithm you have used in determining the answer for (i).   [2 marks]

SECTION B

Question 03 (25 marks)

(a) A software application has different characteristics.

(i) What main characteristic is measured by its algorithm?   [1 marks]

(ii) Name three other important characteristics of a software application.   [2 marks]

(b) Dynamic Programming is a concept which lets you solve certain set of problems efficiently compared to brute forcing and recurrence.

(i) The problem of interest needs to have a certain amount of hallmarks in order to apply Dynamic Programming.

How many hallmarks are there?   [1 mark]
 What are they? Briefly explain each of them.   [4 marks]

(ii) Greedy Algorithms are extensions of Dynamic Programming approaches. What is the hallmark that should be present in order to apply a Greedy Algorithm in addition to those required for Dynamic Programming? Briefly explain.   [2 marks]

(c) Comment on the complexities of the running times of the given algorithms   [15 marks]

(i) $$T(n) = T\left(\left\lfloor \frac{n}{3} \right\rfloor\right) + T\left(\left\lceil \frac{3n}{9} \right\rceil\right) + n$$

(ii) $$T(n) = T\left(\frac{n}{2}\right) + T\left(\frac{n}{3}\right) + n^2$$ **Note:** Here a rough estimation is sufficient.

(iii) $$T(n) = T(\sqrt{n}) + n$$

Question 04 (25 marks)

(a) Sorting is a famous problem looked at extensively in the study of algorithms. Insertion sort and bubble sort are two simple comparison sorting algorithms.

(i) Write the pseudo code for insertion sort.   [4 marks]

(ii)   What is the best case scenario and the worst case scenario for insertion sort? State and briefly verify the running times of the two scenarios.   [3 marks]

(b)   In bubble sort, starting from the first element, neighbouring pair is compared. If the first element is larger, then the positions of the elements are swapped. This ensures that the biggest element goes to the last position of the array after the first pass.

In the second pass the process will be repeated for all elements other than the last element. Subsequent passes are repeated until no swaps are needed.

The pseudo code for the bubble sort is given below.

BUBBLE-SORT(A)
        for i ← 1 to length[A]
           do for j ← 1 to length[A] – i
                 do if A[j] > A[j+1]
                       then temp ← A[j]
                               A[j] ← A[j+1]
                               A[j+1] ←temp

(i)   What are the best case and worst case running times of bubble sort? Briefly verify your answers.   [2 marks]
(ii)   Apart from running times, give one similarity and dissimilarity between insertion sort and bubble sort.   [2 marks]
(iii)   What algorithm do you think is more efficient? Explain your answer.   [3 marks]

(c)   An array A[1…n] contains all the integers from 0 to n, except one. We need to determine which integer is missing.

But we can't access an entire integer in A with a single operation. The elements are represented in binary. The only operation we can use to access them is "fetch the jth bit of A[i]", which takes a constant time.

(i)   Explain how you would solve the problem with a complexity of O(n).   [6 marks]
(ii)   Put your proposed solution into pseudo code   [5 marks]

Hint: One way of solving the problem involves recursion. You may roughly verify that the complexity of the recursion method is O(n) in order to verify your answer. (You don't need to show these steps in the answer scripts)