BITS, Pilani – Dubai Campus
Knowledge Village, Dubai

Third Year (Computer Science & Engg.)
First Semester, 2006-2007

Comprehensive Examination (Closed Book)

Course No: CS UC341 | **Course Title: Data Structures and Algorithms**
Date: 26th Dec 2006 | **Weightage: 40%**
Duration: 3 Hours | **Max. Marks. 40**

Write answers to all questions, including answers to question no.1, in the main answer book only

1.

(a) $20\,n^5 + 10\,n \log n + 5 + n^4\sqrt{n} + 2^n$ is of order O(--------).

(b) A stack is a container of objects that are inserted and removed according to the ------ ----- -------- ------ principle.

(c) Sequence ADT includes all methods of --------- and ---------- ADTs.

(d) The number of external nodes in a (proper) binary tree T with n nodes and height h is at least ------- and at most ----------.

(e) Which of the following operations on a heap has least run-time complexity?
insertItem, removeMin, minElement

(f) The mapping that converts the hash code to an integer within the range of indices of a bucket array is called ---------- ------.

(g) What operation is used to rebalance an AVL tree after inserting a node?

(h) In spite of its poor worst-case performance, splay trees perform well in ---------- analysis.

(i) What is the solution of the following recurrence relation?

$t(n) = b$ if $n=1$
$= 2\,t(n/2) + cn$ otherwise

(j) What is the run-time complexity of the greedy algorithm for solving the fractional knap-sack problem with n items?

(k) Dynamic programming algorithm for solving 0-1 knap-sack problem is called ---------- ---------- algorithm since its running time depends on the magnitude of a number given in the input.

(l) What is the minimum number of edges required to get an undirected connected graph with n vertices?

(m) What is the storage required to represent a graph with n vertices and m edges by the adjacency matrix structure?

(n) List at least two graph problems that can be solved by DFS.

[PTO]

(o) What is the run-time complexity of Dijkstra's algorithm for finding all shortest paths from a vertex v in a graph G with n vertices and m edges?

(p) Name the heuristics used by Boyer-Moore algorithm for pattern matching.

(q) What is the characteristic property that defines a compressed trie?

(r) A coding scheme in which no code word is a prefix of another code word is called a ------ ---------.

(s) A computational problem for which the intended output is "yes" or "no" is called a ------- problem.

(t) What is the name of the complexity class that contains all languages (problems) whose complements are in NP?

(20 x 0.5 = 10 marks)

2. Use in-place heap sort to sort the following array.

   3, 13, 8, 11, 7, 2

   Show the results after each step.

   (5 marks)

3. Describe an efficient greedy algorithm for making change for a specified value using a minimum number of coins, assuming there are four denominations of coins with values 25, 10, 5, and 1.

   Give an example set of denominations of coins so that a greedy change-making algorithm will not use the minimum number of coins.

   (3+2 marks)

4. Insert the following keys, in the order given, into an initially empty (2, 4) tree. Draw the tree after each insertion.

   5, 16, 22, 45, 2, 10, 18, 30, 50, 12, 1

   (5 marks)

5. A weighted undirected graph G with seven vertices 1, 2, 3, ..., 7 has 13 edges as given below.

Edge	(1,2)	(1,3)	(1,4)	(1,7)	(2,3)	(2,6)	(3,4)	(3,6)	(4,5)	(4,7)	(5,6)	(5,7)	(6,7)
Weight	3	15	18	27	13	23	8	11	7	9	10	2	12

   (a) Draw the graph G.

   (b) Find the minimal spanning tree of G by Kruskal's algorithm. **(1+4 marks)**

6. Draw standard and compressed tries for the following set of strings.

   {abab, baba, cccc, bbaaaa, caa, bbaacc, cbcc, cbca}

   (3+2 marks)

7. Describe the two steps to show that a problem is NP-Complete. Give two examples of NP-Complete problems. State the problems clearly and precisely, but no proof is required.

   (2+2+1 marks)

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Test 2 – Makeup (Open Book)
(Permitted to refer the text book and class notes)

Course No: CS UC341 **Course Title: Data Structures and Algorithms**
Date: Nov 2006 **Weightage: 20%**
Duration: 50 minutes **Max. Marks. 20**

1. (a) Let T be a binary tree with height h and n nodes. Show that
$\log(n+1) - 1 \leq h \leq (n-1)/2$
(b) For which values of n and h can the above lower and upper bounds on h can be attained with equality? **(4 marks)**

2. Illustrate the inplace heap sort algorithm on the following input sequence:
(2, 5, 16, 4, 10, 23, 39, 18, 26, 15) **(6 marks)**

3. Draw the 11-item hash table resulting from hashing the keys 12, 44, 13, 88, 23, 94, 11, 39, 20, 16, and 5 using the hash function h(i) = (2i+5) mod 11 and assuming collisions are handled by chaining. **(3 marks)**

4. Let S = {a, b, c, d, e} be a collection of objects with benefit-weight values as follows: a:(12, 3), b:(10, 5), c:(8, 4), d:(11, 6), e:(14, 2). Use dynamic programming to find the optimal solution to the **0-1 knapsack** problem for S assuming we have a sack that can hold objects with a total weight 10. Show the calculations in the form of a table. **(4 marks)**

5. Sally is hosting an Internet auction to sell n widgets. She receives m bids, each of the form "I want ki widgets for di dollars," for i = 1, 2, …., m. Characterise her optimisation problem as a knapsack problem. Under what condtions is this a 0-1 versus fractional problem? **(3 marks)**

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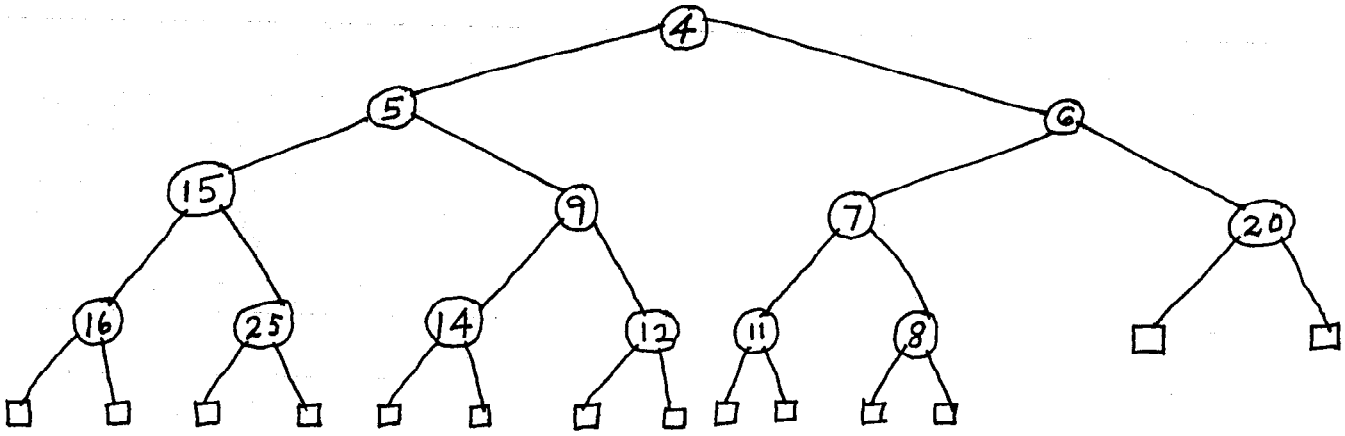
Test 2 – Regular (Open Book)
(Permitted to refer the text book and class notes)

Course No: CS UC341 — **Course Title: Data Structures and Algorithms**
Date: 12th Nov 2006 — **Weightage: 20%**
Duration: 50 minutes — **Max. Marks. 20**

1. Let T be an ordered tree with more than one node. Is it possible that the preorder traversal of T visits the nodes in the same order as the post order traversal of T? If so, give an example; otherwise argue why this cannot occur. Likewise, is it possible that the preorder traversal of T visits nodes in the reverse order of post order traversal of T? If so, give an example; otherwise argue why this cannot occur. **(4 marks)**

2. Show the steps for the following operations on the heap given below.
   (a) Remove key 16.
   (b) Replace key 5 with key 18 in the original tree (i.e. tree before doing the operation given in part (a)). **(3 marks)**



3. Draw the 11-item hash table resulting from hashing the keys 12, 44, 13, 88, 23, 94, 11, 39, 20, 16, and 5 using the hash function h(i) = (2i+5) mod 11 and assuming collisions are handled by quadratic probing, up to the point where the method fails because no empty slot is found. **(4 marks)**

[PTO]

4. Use dynamic programming to find the minimum number of multiplications required to multiply the chain of matrices A_0, A_1, A_2, A_3 with dimensions 10 x 5, 5 x 2, 2 x 20, and 20 x 12. Show the values of $N_{i\,j}$ in the form of a table. Express the best method using parentheses.

(6 marks)

5. Suppose that we are given a set of tasks specified by pairs of start times and finish times as T = {(1,2), (1,3), (1,4), (2,5), (3,7), (4,9), (5,6), (6,8), (7,9)}. Solve the task-scheduling problem for this set of tasks using the greedy method. Show the result using a diagram.

(3 marks)

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Test 1 Question Paper

Course No: CS UC341 | **Course Title: Data Structures and Algorithms**
Date: 1st Oct 2006 | **Weightage: 20%**
Duration: 50 minutes | **Max. Marks. 20**

1. Give a big-Oh characterization, in terms of n, of the running time of the Loop method given below. Give the important steps in the derivation of the final result.

```
Algorithm Loop(n):
  s ← 0
  for i ← 1 to n^2 do
    for j ← 1 to i do
      s ← s+i
```

(4 marks)

2. Specify the Vector Abstract Data Type by listing the four fundamental methods of this ADT. Give one sentence specification of each method. **(4 marks)**

3. Sort the following array of integers using in place Quick-sort. Use the last element of the array as the partitioning element. Show all the intermediate steps.
   2, 5, 16, 4, 10, 23, 39, 18, 26, 15
   (4 marks)

4. Write algorithms in pseudo-code for **push** and **pop** operations on a stack that is implemented by a singly linked linear list having a header node. **(5 marks)**

5. Draw a tree with a height of minimum two and at least two nodes having more than two children. List the nodes of the tree using preorder and postorder traversal.

(3 marks)

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