ADVANCED PROGRAMMING & PROBLEM SOLVING
(CSEN 5104)

Time Allotted: 3 hrs **Full Marks: 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and
Any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) When run on an array of n keys, the heapsort algorithm has a worst-case time complexity of
(a) $O(n^2)$ (b) O(n) (b) O(n lg n) (d) O(lg n).

(ii) A queue is an appropriate data structure for use in a program that implements
(a) depth-first search (b) breadth-first search
(c) in-order tree traversal (d) heapsort.

(ii) Stack works on the principles of :
(a) FCFS (b) LIFO (c) Both (A) & (B) (d) none.

(iv) In which notation operator comes after operand?
(a) Infix (b) Prefix (c) Postfix (d) none.

(v) In linked lists there are no NULL links in
(a) singly linked list (b) doubly linked list
(c) circular linked list (d) none.

(vi) In a rooted tree T having 45 nodes, every internal node has either 2 or 3 children. If the tree is drawn growing downwards and the root has height 0, the height of T must be at least
(a) 6 (b) 5 (c) 4 (d) 3.

(vii) A full binary tree with n leaves contains
(a) n nodes (b) $\log_2 n$ nodes
(c) $2n - 1$ nodes (d) $2n + 1$ nodes.

(viii) A binary search tree T is first traversed in in-order and then in post-order. It is found that the sequence in which the nodes are visited is *not* identical in the two traversals. Then it must be the case that
(a) at least one internal node in T has a left child;
(b) at least one internal node in T has a right child;
(c) at least one internal node in T has both a left child and a right child;
(d) T has just one node, namely the root node.

(ix) Language C uses
(a) call by value (b) call by reference
(c) call by name (d) none of these.

(x) A binary tree T having 20 nodes is stored in a 20x20 matrix M in the following form: M(j,k) = 1 if node k is a child of node j in T, and M(j,k) = 0 otherwise. Then the number of 0's in matrix M is
(a) 20 (b) 225 (c) 347 (d) 381.

Group - B

2. (a) Construct a binary search tree T with the sequence of keys shown below. Give a diagram of T. Note that two keys 15 and 31 appear twice in the sequence; both occurrences should be inserted in the binary tree.

31 15 23 45 12 26 15 16 31 28 18 22

(b) Draw a flowchart (or give an algorithm in outline) for your insertion procedure.

(c) Determine the average number of comparisons for a successful search in the tree T that was constructed in part (a) above, assuming each of the ten distinct keys are searched with equal likelihood.

(4 + 4 + 4) = 12

3. (a) Consider the following arithmetic statement in infix notation:

$$a = b / c + (d - e) \wedge (c * b)$$

The binary arithmetic operators +, -, *, / have their usual meaning; ^ (caret) represents exponentiation and '=' the assignment operator. Single characters represent variables.Explain how the above statement can be converted into the Polish postfix notation with the help of a stack.

(b) Suppose the current values of the integer variables are as follows:

Variable	***b***	***c***	***d***	***e***
Value	**9**	**2**	**6**	**3**

Explain how the Polish postfix expression obtained above can be evaluated (using integer calculation), and the value of *a* determined with the help of a stack.

7 + 5 = 12

Group - C

4. (a) How does a B-tree differ from a binary tree? How is the order of a B-tree defined?

   (b) Construct a B-tree of order 7 with the following 14 keys:

   21 4 3 7 6 35 19 45 32 55 17 40 8 11.

   (c) Delete the node containing key 17 from the B-tree just constructed and show the modified B-tree.

4 + 6 + 2 = 12

5. (a) Construct a Red-Black (RB) tree T with the input sequence of eight keys given below:

   4 3 6 5 1 8 2 7

   (b) Let us get a new binary tree T' from T by deleting the colours of the nodes. Is T' necessarily an AVL tree?
   Is it possible to convert every AVL tree into a Red-Black tree by appropriately colouring the nodes?

6+ (3 + 3) =12

Group - D

6. (a) How does hash search differ from Binary or Linear search?

   (b) The following Hash functions are given for a Double Hashing case where the hash table size is 13:

   h1 = (key mod 13) h2 = 1 + (key mod 11)

   Show the configuration of the Hash Table after the following values are inserted:

   79 69 72 50 98

   (c) Determine the total number of collisions that occur when these insertions are made.

2 + 7 + 3 = 12

7. (a) The two recursive functions g(.) and h(.) both take the positive integers as domain and the integers as range, and are defined by simultaneous recursion as follows:

   $g(1) = 3$

   $g(n+1) = h(n) + n - 2$ when $n > 1$

   $h(1) = 4$

   $h(n+1) = g(n) + (-1)^n.(n - 1)$ when $n > 1$

The function f(.) also takes the positive integers as domain and the integers as range and is defined as follows:

$f(n) = h(g(n) - 1) + 1$ when $n >= 1$

What are the values of f(4) and f(7)? Is f(n) an increasing function of n, i.e., is $f(n+1) > f(n)$ always for $n \geq 1$?

(b) Write a program in C that, when supplied a positive integer n as input, will compute and output f(n).

(2 + 2 + 2) + 6 = 12

Group - E

8. (a) What do you mean by friend function? What is the significance of declaring a function as friend? Give example.

   (b) Write a function in C++ to swap the values of a pair of integers using reference variable as arguments.

   (c) Create a class called TIME that has separate data member for hours, minutes and seconds. There are two member functions. One of them is used to display the time in the format hh:mm:ss. The other member function should add two objects of type TIME passed as arguments. Write a program in C++ to do this.

(1 + 2) + 3 + 6 = 12

9. Write a program in C or C++ to solve the problem stated below:

   The input is a sequence of characters (which can also be viewed as a character string) that consists of an English sentence. Words begin with upper/lower case letters and are separated by one or more blanks. There might be punctuation marks such as comma or semicolon, and the sentence is terminated by a full stop. Your program should find and output the longest word in the given sentence that does not contain any of the following three letters 'k', 'r' and 't' (in upper or lower case).

   For example, the sentence might be as follows:

   "My aunt, who lives in North Kolkata, has not been keeping well lately; next Monday I plan to visit her in the morning to find out whether her health has improved."

   With this input the program should output the word 'Monday'.

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