M.TECH/CSE/1ST SEM/CSEN 5104/2016

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) $O(n)$ (c) $O(n \log n)$ (d) $O(\log n)$.

(ii) Let T be a binary search tree with n nodes. An in-order tree traversal algorithm when run on T will take time proportional to
(a) n (b) lg n (c) n lg n (d) n^2.

(iii) We can always sort three integers using pairwise comparisons in at most k steps where k is
(a) 6 (b) 4 (c) 3 (d) 2.

(iv) The number of nodes in a complete ternary tree T (each non-leaf node has exactly 3 child nodes and all leaf nodes are at the same level) of depth 4 (considering root node is of depth 1) is
(a) 120 (b) 40 (c) 39 (d) 13.

(v) Consider the following C program:

```
for (i = 0; i <= 6; i++)
  {
    if (i%3)  continue;
    printf("%d ", i);
  }
```

The program will display the following output:
(a) 0 1 2 3 4 5 6 (b) 1 2 4 5
(c) 0 3 6 (d) none (i.e., no output will be displayed).

(vi) A binary search tree T is first traversed in in-order and then in pre-order. It is found that the sequence in which the nodes are visited is identical in the two cases. Then it must be the case that
(a) no node in T has a left child
(b) no node in T has a right child
(c) every internal node in T has two children
(d) T just has a root node and no other node.

(vii) The total number of chords of a regular octagon is
(a) $^8C_2$ (b) $^7C_2$ (c) $^8C_2 - 8$ (d) $^7C_2 + 8$.

(viii) A positive integer n when expressed in binary notation has 11 binary digits (with no leading zeroes). If n is now expressed in octal (i.e. radix 8) notation, the number of octal digits will be
(a) 3 (b) 5 (c) 4 (d) 6.

(ix) N random positive integers are inserted into a hash table of size M using open addressing with double hashing. Given that N is much smaller than M, the average time for a successful search of an entry in the hash table is
(a) O(lg n) (b) O(n) (c) O(n lg n) (d) O(1).

(x) A circularly linked list is a convenient data structure for representing
(a) a sorted table of integers (b) a stack
(c) a queue (d) a deque.

Group – B

2. (a) The following arithmetic statement given in infix notation is to be converted into the Polish postfix notation using a stack:

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

All operator symbols have their usual meaning; '^' (caret) represents the exponentiation operator. Single characters represent variables. Explain how the conversion into the postfix notation can be accomplished.

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

Variable	*b*	*c*	*d*	*e*	*f*	*g*
Value	6	6	5	3	3	1

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

6 + 6 = 12

3. (a) The six integers 31 4 12 57 8 22 are read in one by one and pushed into a stack in the given left-to-right order. The stack is then popped four successive times and each integer as it comes out is inserted into a queue. Then two integers are deleted from the queue and pushed back into the stack in the order in which they are deleted from the queue. If we now pop the stack twice, which integer will be the last one to be popped? Explain with the help of a figure.

(b) Give recursive algorithms for traversing a given binary tree T in pre-order, in-order and post-order. Next give a non-recursive algorithm for traversing T in in-order.

4 + (1 + 1 + 1 + 5) = 12

Group – C

4. (a) Construct a B-tree of order 5 with the following sequence of 16 keys: 110, 40, 80, 130, 100, 50, 190, 90, 180, 240, 30, 120, 140, 20, 210, 160.

(b) Why do we prefer to use B-trees to store data in secondary storage? A B-tree of order three has 20 keys. What are the smallest and largest possible heights of T?

6 + (3 + 3) = 12

5. (a) Construct a Red-Black (RB) tree with the input sequence of 8 keys given below:

49 37 68 51 15 22 55 70

(b) How does a Red-Black tree differ from an AVL tree? Is every AVL tree a Red-Black tree? Is every Red-Black tree an AVL tree?

6 + (2 + 2 + 2) = 12

Group – D

6. (a) Insert the following 13 keys into a hash table TAB of size 17 (i.e., the table starts from TAB[0] and goes up to TAB[16]) using the open addressing method with linear probing:
20, 105, 32, 45, 58, 126, 3, 29, 221, 74, 66, 92, 18
Determine the average number of comparisons for a successful search.

(b) Explain the meaning of the following three terms with illustrative examples:
(i) primary clustering
(ii) secondary clustering
(iii) quadratic probing.

(4 + 2) + (2 + 2 + 2) = 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 as follows:

$g(n) = 2$ when $n = 1$
$g(n+1) = g(n) + 2n - 3$ when $n > 1$
$h(n) = 5$ when $n = 1$
$h(n+1) = h(n) + (-1)^n.n$ when $n > 1$

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

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

What are the values of f(5) and f(8)?

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

6 + 6 = 12

Group – E

8. (a) The following questions relate to the programming language C++. Answer them giving appropriate illustrative examples in each case.
(i) What is the need for data hiding and how is it accomplished in C++?
(ii) When would you want to declare a data item as private?
(iii) When would you want to declare a data item as static?

(b) (i) What is meant by a parameterized constructor? When is such a constructor useful?
(ii) Can a class definition in C++ contain more than one constructor? What is gained by allowing multiple constructors in a class definition?
(iii) What is a friend function in C++?

(2 + 2 + 2) + (2 + 2 + 2) = 12

9. A string *s* that is supplied as input consists of an English passage and contains only alphabetic characters, blank spaces, and punctuation marks like comma and full stop. You have to determine the two letters of the alphabet that occur most frequently in the passage; both upper case and lower case occurrences should be counted. For example, suppose *s* is the following passage:
"We found the baby girl at last all spattered with mud in a corner of the garden. She was happily playing hide-and-seek with the cat."
Write a program in C or C++ to solve the problem. For the above passage your program should output the message:
"The two most frequently occurring letters in the given passage are 'e' and 'a'."

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