Ref. No.: Ex/IT/PC/B/T/211/2025

B.E. Information Technology Second Year First Semester 2025

Sub: Data Structures and Algorithms

Time: 3 Hours | Full Marks: 100

Answer all Questions

1. Answer either (a) or (b)

a. (3+ 3 + 10 + 6 + 3)

i. Define the following:

Best Case, Worst Case, and Average Case Analysis.

ii. Derive the time complexity of the following code in big-Oh notation?

```
for (i = 1; i <= n; i++)
{
  for (j = 1; j < n; j = j + i)
  {
    Printf ("%d %d", i, j);
  }
}
```

iii. There are n houses built in a line, each of which contains some money in it. You are a professional robber planning to steal money from these houses, but you can't steal from two adjacent houses. Use recursion, to develop an algorithm to find the maximum amount of money which you can steal.

iv. Write an algorithm to find the middle element of a linked list in a single pass?

v. List some advantages and disadvantages of doubly linked list over singly linked list.

b. (3 + 6 + 4 + 10 + 2)

i. Define Big-Oh, Ω, and Θ notations for time complexity.

ii. Given an unsorted array, write an algorithm to find peak elements in it. An element is considered to be peak if its value is greater than or equal to the values of its adjacent elements (if they exist). There can be more than one peak elements in an array, you must find all of them.

iii. Given an array of size n-1 with integers in the range of [1, n], Write an algorithm to find the missing number from the first n integers.

iv. Given a linked list and a value **x**, write an algorithm to partition it such that all nodes less than x come first, then all nodes with a value equal to x, and finally nodes with a value greater than x. The original relative order of the nodes in each of the three partitions should be preserved.

v. Give some examples where array beats linked list.

2. (5 + 5 + 5 + 5)

a. Given a string, str, write an algorithm using stack to remove all duplicate adjacent characters from the given string.

b. Given a queue Q_1 and another empty queue Q_2 and a variable temp, write a function that returns Q_1 but its elements reversed.

c. Consider the following function:

```
int fib(int n)
{   if (n == 0)                 return 0;
    if (n == 1 || n == 2)       return 1;
    else                        return (fib(n - 1) + fib(n - 2));
}
```

Show the content of the stack when fib(5) is called.

d. Evaluate the postfix expression 2 4 * 9 5 + - using stack.

3. Answer either (a) or (b)

a. (5 + 4 + 9 + 4)

i. Write an algorithm to find the in-order successor of a given node of a binary tree. Your algorithm must consider the fact that the left sub-tree of the given node may or may not be empty. You may modify the structure of a node of binary tree.

ii. The pre-order traversal sequence of a binary search tree is: 30, 20, 10, 15, 25, 23, 39, 35, 42. Give the post order traversal sequence of the binary search tree.

iii. Insert the following keys into an initially empty B tree of order 4.

1 12 8 2 25 6 14 28 17 7 52 16 48 68 3 26 29 53 55 45

iv. The elements 32, 15, 20, 30, 12, 25, 16 are inserted one by one in the given order into a max-heap. Show the resultant max-heap. Finally delete 32 and restore the max-heap property.

b. (7 + 6 + 5 + 4)

i. Insert the following keys in an AVL tree:

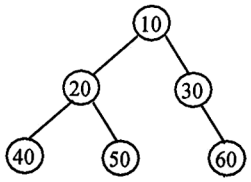
1, 10, 6, 3, 2, 20, 15, 18, 12

ii. Show that the time complexity of BuildHeap() function to create a heap is O(n).

iii. Write an algorithm to compute the maximum height of a given binary tree.

iv. Consider the foo function and binary tree shown. When foo is called with a pointer to the root node of the given binary tree, what will it print?

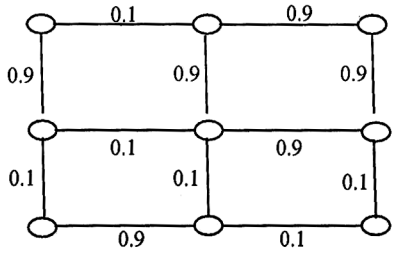
```
int foo(node *p)
{
  int retval;
  if (p == NULL)
        return 0;
  else
  {
        retval = p->val + foo(p->left) + foo(p->right);
        printf("%d ", retval);
        return retval;
  }
}
```



4. (10 + 5)

a. You are given an mxn grid where each cell can assume a value 2 to represent rotten potato, 1 to represent fresh potato, 0 to represent empty cell. A rotten potato at index **(i,j)** can rot other fresh potatoes which are its neighbors (up, down, left, and right). Using the concept of BFS technique, write a function to find out the minimum amount of time required such that none of the cells has a fresh potato. If it is not possible to rot all potatoes, return -1.

b. Consider the following undirected graph with edge weights as shown. What is the number of minimum-weight spanning trees of the graph? Draw the minimum-weight spanning trees.



5. Answer either (a) or (b)

a. (5 + 9 + 4)

i. Show that the time complexity of merge sort algorithm is O(nlogn)

ii. Run the Quick sort algorithm on the following array to arrange the numbers in decreasing order.

30 60 10 40 20 90 80 100

iii. Consider a hash table with 100 slots. Collisions are resolved using chaining. Assuming simple uniform hashing, what is the probability that the first 3 slots are unfilled after the first 3 insertions?

b. (9 + 5 + 4)

i. Run the heap sort algorithm on the following array to arrange the numbers in decreasing order.

50 30 60 10 40 20 90 80 100 70

ii. Given two strings s1 and s2 consisting of lowercase characters, the task is to check whether the two given strings are anagrams of each other or not. An anagram of a string is another string that contains the same characters, only the order of characters can be different.

iii. Consider a hash table with 100 slots. Collisions are resolved using linear probing. Assuming simple uniform hashing, what is the probability that the first 3 slots are unfilled after the first 3 insertions?