Indian Statistical Institute

Semester Examination: 2025 – 2026

Bachelor of Mathematics, Semester VI

Elective (E8): Data Structures and Algorithms

Date: 05 May 2026 Maximum Marks: 100 Duration: 3 hours

Attempt all the questions. Credit will be given for precise and brief answers. Provide diagram wherever appropriate.

1. (a) Determine what the following recursive C function computes. Write an iterative function to accomplish the same purpose.

```
func (n)
    int n;
    {
     If (n == 0)
        return (0);
     else
        return (n + func (n - 1));
     }
```

3 + 3 = 6

(b) Write the merge sort algorithm and determine its time complexity. 6 + 4 = 10

2. Write an algorithm to determine if an input character string of the form x C y (gaps in between characters signify 'space' character), where x is a string consisting of letters 'A' and 'B', and where y is the reverse of x (that is, if x = ABABBA, y must be equal to ABBABA). At each point you may read only the next character of the string. 12

3. Convert the infix expression ((A + B) * C – (D – E)) $ (F + G) to postfix. Convert the prefix expression + – * $ ABCD // EF + GH to infix. The operators are to be evaluated in usual order. In both the cases use stack to describe the steps. 6 + 6 = 12

4. A binary tree whose every nonleaf node has nonempty left child and nonempty right child is known as a *strictly binary tree*.
(a) Prove that a strictly binary tree with n leaf nodes contains a total of 2n - 1 nodes. 5
(b) Given a strictly binary tree with n leaves, let level(i) for i between 1 and n equals the level of the i'th leaf. Prove that 7

$$\sum_{i=1}^{n} \frac{1}{2^{level(i)}} = 1$$

.

5. (a) Describe an algorithm to balance a binary search tree, where the difference of heights between the left and right subtrees of the root node cannot be more than 1. 8
(b) Construct the inorder traversal tree of the expression (A + B * C) $ ((A + B) * C). Operators are to be valuated in usual order. 4

6. Determine time and memory complexity of breadth-first and depth-first search algorithms. 4 + 2 + 4 + 2 = 12

7. Describe hash data structure with one conflict resolution scheme. 8 + 4 = 12

8. (a) Let G = (V,E) be a directed or undirected graph, and let s is in V be an arbitrary vertex. Then, show that for any edge (u,v) in E, $d(s,v) \leq d(s,u) + 1$, where d denotes the shortest path. 4
(b) The transpose of a directed graph G = (V,E) is the graph $G^T = (V,E^T)$, where $E^T = \{(v,u) \in V \times V : (u,v) \in E\}$. Thus, G^T is G with all its edges reversed. Describe a time efficient algorithm for computing G^T from G, where G is represented as adjacency matrix. Also give the time complexity of the proposed algorithm. 8