Ex/PG/ITE/PC/T/111/2025

M.E. INFORMATION TECHNOLOGY FIRST YEAR FIRST SEMESTER - 2025

DATA STRUCTURES AND ALGORITHMS

Time: 3 hours **Full Marks: 100**

CO1 Explain and discuss the concepts of data structures, algorithms and analysis of the algorithms [25]

1. Any one (1) [5]
   a. Find the bound of H_n.
   b. Convert the following function 'F()' into an equivalent iterative function.

```
F(x)
{
        if (P(x))
                return G(x);
        return F(H(x));
}
```

2. Attempt (a) and [b or c] [3+7=10]
   a. What is amortise analysis? What are the objectives of this type of analysis?
   b. Use accounting method to analyze the implementation of queue using two stacks.

   or

   c. Use potential method to analyze the binary counting problem.

3. Attempt ant two (2) [5+5=10]
   a. Assume that the set I of integer is a basic data type available to you. Using the definition of the rational number, define ADT of rational number.

   b. A tri-diagonal matrix is a square matrix whose non-zero elements lie on one of three diagonals: main diagonal: i = j; diagonal below main diagonal: i = j+1; diagonal above main diagonal: i = j-1. Design a mechanism to transform the representation of tri-diagonal matrix into 1-D array.

   c. Convert the following arithmetic expression into post-fix expression assuming the information given in table.

Operators	Priority	Associativity
+, -	1 (more priority)	Left to right
*, /	2 (less priority)	Left to right

Infix expression: A + B * C – D / E + F – G

CO2 Understand and illustrate the use of advanced and augmented data structures. [20]

4. Attempt any two (2) [10 + 10]
   a. Augment the binary search tree to solve the order statistics problem. Write the search algorithm on the modified binary search tree to solve the order statistics problem.
   b. Prove that in AVL tree height remains same if insertion is followed by a rotation operation.
   c. Design a probabilistic data structure for efficient insertion, deletion and searching.

CO3 Apply different algorithm techniques to solve problems. [30]

5. Attempt any three (3) [10+10+10]
   a. Select a sample of m elements randomly from a set of n elements, where m < n. Prove that expected number of trials to select m elements is O(n). [10]
   b. State 'Verifying matrix multiplication' problem. Give a randomized algorithm to solve the problem. What is the complexity of the method? How the probability of error can be reduced? [2+3+2+3]
   c. State the 'Counting inversions problem'. Design a divide and conquer approach to solve the problem. Count the inversion pairs in the given sequence: 4, 1, 5, 2, 6, 3, 8, 7 (respect to the increasing order). [2+3+5]
   d. Design an algorithm to solve the activity selection problem. Find the complexity of the proposed method. Select optimum number of activities from the given activities {(1, 4), (2, 14), (3, 5), (3, 8), (4, 6), (5, 7), (7, 9), (8, 12), (8, 13), (10, 11), (13, 15)}. [5+5]
   e. Construct an optimal binary search tree for the data give below. Show the computation step-by-step.

(a_1, a_2, a_3, a_4) = (end, goto, print, stop) and				
$p(a_1)=0.05$,	$p(a_2)=0.2$,	$p(a_3)=0.1$,	$p(a_4)=0.05$,	
$q(0)=0.2$,	$q(1)=0.1$,	$q(2)=0.2$,	$q(3)=0.05$,	$q(4)=0.05$

CO4 Describe and express the concept of NP-completeness and Approximation algorithms. [25]

6. Define any one (1) [5]
   a. Polynomially reducibility of a problem
   b. Class APX.
7. Attempt any two (2) [10+10]
   a. Prove that 0-1 Knapsack problem belong to class APX.
   b. State and prove that set cover problem in NP-complete. Clearly mention your assumptions.
   c. Polynomially reduce the following Boolean expression into an instance of the independent set problem.

$$(x_1 + \overline{x_2} + x_3 + x_4)(x_1 + x_3 + \overline{x_4} + x_5)(x_2 + \overline{x_3} + \overline{x_4} + x_5)(x_1 + \overline{x_2} + x_3 + \overline{x_5})$$