

Program: Computer Science & Engineering (Data Science)	T. Y. B.Tech	Semester: V
Design and Analysis of Algorithms (RCP23DCPC502)		
Design and Analysis of Algorithms Laboratory (RCP23DLPC502)		

Prerequisite: Computer Programming, Data structures

Course Objective(s):

1. To provide mathematical approach for Analysis of Algorithms.
2. To introduce important algorithmic design paradigms and approaches for effective problem solving.
3. To introduce the concepts of tractable and intractable problems and the classes P, NP and NP-complete problems.

Course Outcomes:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Analyze the performance of algorithms by solving recurrence relations with various methods.	L4	Analyze
CO2	Solve the problem using appropriate algorithmic design techniques.	L3	Apply
CO3	Able to prove that certain problems are NP-Complete.	L3	Apply

Design and Analysis of Algorithms (RCP23DCPC502) Course Contents

Unit-I

06 Hrs.

Introduction:

Methods for solving recurrence relations using tree, substitution, master method Problem Solving using divide and conquer algorithm: – Binary search, Quick sort, Merge Sort, Randomized Quick Sort, Analysis of Binary search, quick sort and merge sort.

Unit-II

06 Hrs.

Graph and Tree Algorithms:

B Tree: Properties of B Tree, Insertion, Deletion and Search Operation on B Tree, B+ Tree: Properties of B+ Tree, Insertion, Deletion and Search Operation on B+ Tree, RB Tree: Properties of RB Tree, Insertion, Deletion and Search Operation on RB Tree, Topological sorting, Applications.

Unit-III

06 Hrs.

Greedy Method:

Introduction, control abstraction, Problem solving using - fractional knapsack problem, activity selection problem, job sequencing with deadline, Minimum Spanning trees (Kruskal's algorithm, Prim's algorithm), Single source shortest path (Dijkstra's algorithm), coin change problem.

Unit-IV

10 Hrs.

Dynamic Programming:

Introduction, principle of optimality, Components of dynamic programming, characteristics of dynamic programming, Fibonacci problem, Coin Changing problem, 0/1 knapsack (table and set method), All pairs shortest paths (Floyd Warshall Algorithm), Single source shortest path (Bellman-Ford Algorithm), Matrix Chain Multiplication, Travelling salesperson problem, Longest Common Subsequence (LCS).

Unit-V

06 Hrs.

Backtracking:

Introduction, Basics of backtracking, N-queen problem, Sum of subsets, Graph coloring, Hamiltonian cycles Generating permutation.

Branch-and-Bound:

Introduction, Control abstraction -LC BB, FIFO BB, LIFO BB, 15 Puzzle problem, 0/1 Knapsack problem, Job Sequencing with Deadline.

Basics of Computational Complexity:

Complexity classes: The class P and NP, Polynomial reduction, NP Completeness Problem, NP-Hard Problems, NP Completeness problem using Travelling Salesman problem (TSP), Approximation algorithm using TSP.

Design and Analysis of Algorithms Laboratory (RCP23DLPC502)**List of Laboratory Experiments****Suggested Experiments:(Any 8)**

1. Implementation of randomized quick sort.
2. Implementation of minimum spanning tree algorithm – Prim’s and Kruskal’s using greedy approach.
3. Fractional Knapsack implementation using greedy approach.
4. Implementation of Activity selection using greedy approach.
5. Implementation of job sequencing with deadline using greedy approach.
6. Implementation of Single source shortest path (Dijkstra’s algorithm)
7. Implementation of Bellman Ford algorithm using Dynamic programming
8. Implementation of Longest Common Subsequence algorithm using Dynamic programming.
9. Implementation of Travelling Salesperson problem using Dynamic programming.
10. Implementation of multistage graphs/ all pair shortest path using dynamic programming.
11. Implementation of N-queen problem using Backtracking.
12. Given an integer array num of 2n integers, group these integers into n pairs (a1, b1), (a2, b2), ..., (an, bn) such that the sum of min (ai, bi) for all i is maximized. Return the maximized sum.
(Using LeetCode Platform)
13. Determine if a 9 x 9 Sudoku board is valid. Only the filled cells need to be validated according to the following rules:
 1. Each row must contain the digits 1-9 without repetition.
 2. Each column must contain the digits 1-9 without repetition.
 3. Each of the nine 3 x 3 sub-boxes of the grid must contain the digits 1-9 without repetition.

14. Given an $m \times n$ grid of characters' board and a string word, return true if word exists in the grid. The word can be constructed from letters of sequentially adjacent cells, where adjacent cells are horizontally or vertically neighboring. The same letter cell may not be used more than once.
15. Given an array prices where prices[i] is the price of a given stock on the ith day. You want to maximize your profit by choosing a single day to buy one stock and choosing a different day in the future to sell that stock. Return the maximum profit you can achieve from this transaction. If you cannot achieve any profit, return 0.
16. Knuth-Morris-Pratt (KMP) String Matching
17. Implementation of Naive String Matching Algorithm string matching algorithm.
18. Implementation of Selection Sort.
19. Implementation of Bubble Sort.
20. Implement a program to merge two sorted arrays.
21. Implementation of Merge sort algorithm.
22. Implementation of quick sort algorithm.
23. Implementation of Sequential Search method.
24. Implementation of Binary Search method.
25. Multiplying two large integers
26. MIN MAX- Linear Approach
27. MIN MAX- Divide and Conquer Approach
28. Implementation of Strassen's Matrix Multiplication.
29. Implementation of Job Sequencing Problem with Deadlines.
30. Implementation of Job Scheduling.
31. Implementation of Prim's Algorithm.
32. Implement a program for Divide and Conquer Multiplication of two arrays.
33. Implement a program to perform Multiplication of Two Matrices.
34. Road Decoration: Australia and New Zealand have started working on preparation for the World Cup 2015. There are N important venues (like hotels and stadiums) in the city. Out of these important venues, there is one central location where the opening and closing ceremony will be

held. There is an existing network of bidirectional roads connecting these venues. The organizing committee has planned to decorate some of these roads that will be used for commuting. They have decided to choose the roads to decorate such that there is exactly one decorated path to all the venues from the central location. New Zealand is supposed to decorate these roads and Australia has taken up the responsibility of providing transportation. Only decorated roads can be used for transportation. Australia wanted to save fuel costs, and so they wanted to choose the decorated roads to minimize the total sum of distances to all venues from the central location. However, New Zealand had their own plans to minimize decoration cost by choosing the decorated roads such that the sum of the length of the chosen roads will be minimized. To prevent a fight breaking out between these two rivals before they even step on to the field, you have to help them by reporting if there is a solution in which the two rivals could choose the same set of roads while satisfying their respective constraints.

35. Fullmetal Alchemist: After completing the preliminary tests, Full Metal now faces his final exam. Captain Mustang gives him an $n \times m$ grid of letters. He defined distance between two rows of the grid as the largest absolute difference between letters in the same column. Full Metal is assigned to mark all the rows. The cost of marking the first row of his choice is zero. Thereafter the cost of marking each row is equal to the distance of the row (being marked) from any one of the previously marked rows. Help Full Metal to determine the least value of the largest cost of marking a row.
36. Implementation of Huffman Algorithm.
37. Implementation of 0/1 Knapsack problem.
38. Implementation of Optimal Binary Search Trees.
39. Implementation of Optimal Binary Search Trees: You are building a Binary Search Tree consisting of values $1, 2, \dots, N$ that would require the minimum number of operations. You are already provided queries given as an array F of length N - F_i stores the number of search queries asked for value i . Output the minimum number of comparisons that would be required to process all the queries.
40. Implementation of Travelling Salesperson Problem (TSP) using Dynamic Programming.
41. Implementation of Knapsack Problem using Branch and Bound.
42. Travelling Salesman Problem using Branch and Bound.
43. Overview of P, NP and NP-Complete Problems.

Any other experiment based on syllabus may be included which would help the learner to understand topic/concept.

Practical examination will be based on the entire syllabus including, the practicals performed during laboratory sessions.

Text Books:

1. Sanjoy Dasgupta, Christos Papadimitriou, Umesh Vazirani, “Algorithms”, 1st Edition, Tata McGraw- Hill, 2023.
2. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein, “Introduction to Algorithms”, 4th Edition, The MIT Press, 2022.
3. Ellis Horowitz, Sartaj Sahni, S. Rajsekaran, “Fundamentals of computer algorithms”, 1st Edition, University Press, 2018.

Reference Books:

1. S. K. Basu, “Design Methods and Analysis of Algorithm”, 2nd Edition, PHI, 2013.
2. John Kleinberg, Eva Tardos, “Algorithm Design”, Pearson, 1st Edition, 2013.

Web Links:

1. NPTEL Course: https://onlinecourses.nptel.ac.in/noc19_cs47/preview
2. LeetCode: <https://leetcode.com/problem-list>