GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering
Subject Code: 3720216
Semester – II
Subject Name: Advance Algorithms

Type of course: Regular

Prerequisite: UG level course in Algorithm Design and Analysis

Rationale: This course will cover fundamental algorithms that operate on common data structures, for instance sorting and searching; advanced design and analysis techniques; advanced graph matching algorithms including minimum spanning trees and shortest paths; flow networks; and linear programming. In summary, this course will provide exposure to recent trends in problem solving paradigms.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	**Sorting:** Review of various sorting algorithms, topological sorting **Graph:** Definitions and Elementary Algorithms: Shortest path by BFS, shortest path in edge-weighted case (Dijkasra's), depth-first search and computation of strongly connected components, emphasis on correctness proof of the algorithm and time/space analysis, example of amortized analysis.	6
2	**Matroids:** Introduction to greedy paradigm, algorithm to compute a maximum weight maximal independent set. Application to MST. **Graph Matching:** Algorithm to compute maximum matching. Characterization of maximum matching by augmenting paths, Edmond's Blossom algorithm to compute augmenting path.	8
3	**Flow-Networks:** Maxflow-mincut theorem, Ford-Fulkerson Method to compute maximum flow, Edmond-Karp maximum-flow algorithm. **Matrix Computations:** Strassen's algorithm and introduction to divide and conquer paradigm, inverse of a triangular matrix, relation between the time complexities of basic matrix operations, LUP-decomposition.	9
4	**Shortest Path in Graphs:** Floyd-Warshall algorithm and introduction to dynamic programming paradigm. More examples of dynamic programming. **Modulo Representation of integers/polynomials:** Chinese Remainder Theorem, Conversion between base-representation and modulo-representation. Extension to polynomials. Application: Interpolation problem.	10

	Discrete Fourier Transform (DFT): In complex field, DFT in modulo ring. Fast Fourier Transform algorithm. Schonhage-Strassen Integer Multiplication algorithm	
5	**Linear Programming:** Geometry of the feasibility region and Simplex Algorithm **NP-completeness:** Examples, proof of NP-hardness and NP-completeness. **One or more of the following topics based on time and interest** Approximation algorithms, Randomized Algorithms, Interior Point Method, Advanced Number Theoretic Algorithm	**10**
6	Recent Trends in problem solving paradigms using recent searching and sorting techniques by applying recently proposed data structures.	**5**

Reference Books:

1. "Introduction to Algorithms" by Cormen, Leiserson, Rivest, Stein.
2. "The Design and Analysis of Computer Algorithms" by Aho, Hopcroft, Ullman.
3. "Algorithm Design" by Kleinberg and Tardos

4. “Fundamentals of Algorithmics” by Gilles Brassard and Paul Bratley.

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	Analyze the time complexity/performance of different algorithms.	**20%**
CO-2	Determining the appropriate data structure for solving a particular set of problem.	**20%**
CO-3	Categorize the different problems in various classes according to their complexity.	**30%**
CO-4	Insight of recent activities in the field of the advanced data structure.	**30%**

List of Experiments:

- Minimum 10 experiments based on the above contents.
- Mini Project in a group of max. 3 students
- Writing a research paper on selected topic from content with latest research issues in that topic

Major Equipments:

- Latest PCs with related software

List of Open Source Software/learning website:

- https://www.coursera.org/specializations/algorithms
- https://visualgo.net/bn
- https://online.stanford.edu/courses/cs161-design-and-analysis-algorithms