NIRMA UNIVERSITY

Institute:	Institute of Technology
Name of Programme:	BTech (CSE)
Course Code:	3CS515ME24
Course Title:	Graph Theory
Course Type:	Department Elective - II
Year of Introduction:	2024-25

L	T	Practical Component				C
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Course Learning Outcomes (CLO):

At the end of the course, the students will be able to –

1. explain fundamental graph theory concepts, including graph discovery, definitions, set operations, and matrix representations (BL2)
2. apply graph theory to solve connected graphs, shortest path, and weighted graph problems (BL3)
3. analyse properties of trees and graphs with an understanding of combinatorial and geometric aspects (BL4)
4. elaborate the concepts of graph theory and connect them with applications. (BL6)

Unit	Contents	Teaching Hours (Total 45)
Unit-I	**Introduction to Graph Theory**: Discovery of graphs, Definitions, and Set Operations on Graphs: Union, Sum, Complement, Difference, Cartesian Product, Composition, and Fusion. Sub-graphs, Isomorphic graphs, Matrix representations of graphs, Degree of a vertex, directed walks, paths, and cycles, Connectivity in digraphs, Eulerian and Hamilton digraphs, Graphic sequences, Graph-theoretic model of the LAN problem, Havel-Hakimi criterion, Realization of a graphic sequence.	10
Unit-II	**Connected Graphs and Shortest paths:** Connected graphs, Distance, Cut-vertices and cut-edges, Blocks, Connectivity, Weighted graphs, and shortest paths, Weighted graphs, Djkstra's shortest path algorithm, Floyd-Warshall's shortest path algorithm.	09
Unit-III	**Trees:** Properties, Pendant Vertices, Distance and Canters in a tree, Rooted and Binary Trees, Counting Trees, Spanning Trees and Fundamental Circuits, Number of Spanning Trees.	09
Unit-IV	**Planar and Dual Graphs:** Combinatorial vs. geometric Graphs, Planar Graphs, Kuratwoski Graphs, Theorems, Detection of Planarity, Geometric and Combinatorial Dual, Thickness, and Crossings.	07
Unit-V	**Coloring, Covering, and Partitioning:** Basic Definitions, Cliques and chromatic number, Chromatic Polynomials, Mycielski's theorem, Greedy coloring algorithm, Coloring of chordal graphs, Brooks theorem, Edge Colorings, Matchings, Coverings, The four-color conjecture and five-color theorem.	10

Self-Study:
The self-study contents will be declared at the commencement of the semester. Around 10% of the questions will be asked from self-study contents

Suggested Readings/ References:

1. N. Deo, Graph theory with applications to engineering and computer science, Courier Dover Publications
2. JA Bondy and USR Murty, Graph theory with applications. Bulletin of the American Mathematical Society, The Macmillian Press Ltd.
3. Doughlous B. West, Introduction to graph theory, Upper Saddle River, NJ: Prentice Hall.
4. Gary Chartard and Ping Zhang, A First Course in Graph Theory, Courier Corporation.
5. Geir Agnarsson and Raymond Greenlaw, Graph Theory: Modelling Applications, and Algorithms, Pearson/Prentice Hall.

Suggested List of Experiments:

Sr. No.	Title	Hours
1	Use an adjacency matrix and adjacency list to represent the graph. Use any of the representations to find the union, intersection, complement, sum, and difference of two graphs.	02
2	Write a program to check whether two graphs are isomorphic to each other or not.	04
3	Use the Havel-Hakimi theorem and check whether the given degree sequence is graphical or not.	02
4	Write a program to find all the spanning trees of a complete directed graph.	04
5	Write a program to find the minimum cut edges from a given graph. (Use Kerger's Algorithm).	02
6	Write a program to find all the articulation points from a given graph. (Use DFS tree)	04
7	Write a program to check whether the graph is planar or not. Apply elementary reduction and check for the resultant three conditions of planarity.	04
8	Write a program to find the maximum clique from a given graph.	04
9	Write a program to find the chromatic number of a given graph.	02
10	Write a program to apply a four-color conjecture to the LAN topology represented graphically.	02