**Course Title: Graph Theory and its Applications**

**Duration:** 12 weeks (2 hours per week)

**Course Objectives:**

1. Understand the fundamental concepts and terminology of graph theory.
2. Analyze the properties and types of graphs.
3. Explore algorithms for solving graph problems.
4. Investigate practical applications of graph theory in various fields like computer science, network analysis, and engineering.

**Week-by-Week Outline**

**Week 1: Introduction to Graph Theory**

* Definition and history of graph theory.
* Applications in computer science, biology, social networks, etc.
* Basic terminology: vertices, edges, degrees, adjacency, and incidence.

**Week 2: Types of Graphs**

* Directed vs. undirected graphs.
* Weighted graphs, multigraphs, and simple graphs.
* Special types: bipartite, complete, and regular graphs.

**Week 3: Representations of Graphs**

* Adjacency matrix and adjacency list.
* Incidence matrix.
* Comparison of representations and their use cases.

**Week 4: Graph Connectivity**

* Connected and disconnected graphs.
* Components, cut vertices, and cut edges.
* Applications in network reliability and resilience.

**Week 5: Eulerian and Hamiltonian Graphs**

* Eulerian circuits and trails.
* Hamiltonian cycles and paths.
* Algorithms and real-world applications (e.g., traveling salesman problem).

**Week 6: Trees and Spanning Trees**

* Properties of trees and rooted trees.
* Minimum spanning trees (MST): Prim’s and Kruskal’s algorithms.
* Applications in network design and optimization.

**Week 7: Graph Coloring**

* Vertex and edge coloring.
* Chromatic number and its significance.
* Applications in scheduling and resource allocation.

**Week 8: Planarity and Graph Drawing**

* Planar graphs and Euler’s formula.
* Kuratowski’s theorem.
* Applications in circuit design and geographic mapping.

**Week 9: Shortest Path Algorithms**

* Dijkstra’s algorithm.
* Bellman-Ford algorithm.
* Applications in routing and navigation systems.

**Week 10: Network Flow**

* Introduction to flow networks.
* Max flow-min cut theorem.
* Ford-Fulkerson algorithm and its applications.

**Week 11: Advanced Topics in Graph Theory**

* Graph isomorphism and automorphisms.
* Spectral graph theory.
* Applications in data analysis and machine learning.

**Week 12: Applications and Course Review**

* Discussion of advanced applications (social network analysis, bioinformatics, etc.).
* Problem-solving session on comprehensive topics.
* Course review and Q&A.