Mathematics Paper I
Graph Theory
[CORE COURSE]

Semester: II	Credits: 2	Subject Code: BS22003	Lectures: 40

Course Outcomes:

At the end of this course, the learner will be able to:
- Know about the new branch of mathematics - Graph Theory and its applications which will help to construct a strong foundation in the subject.
- Define graphs, digraphs and trees, and identify their main properties.
- Classify different types of graphs and identify the areas of their applications.
- Formulate and relate real life situations with different types of graphs and techniques used in Graph Theory.
- Describe and apply some basic algorithms for graphs.
- Demonstrate different traversal methods for trees and graphs.
- Determine the wide nature of the subject through various key concepts in Graph Theory and their real-life applications.

Unit 1: Introduction to Graphs and Operations on Graphs	8

- Introduction
- Elementary Terminologies and Results
  - Handshaking lemma
  - Corollary of Handshaking lemma
- Types of graph
- Isomorphism- Definition and Problems
- Adjacency & Incidence Matrix
- To check degree sequence (Sequence is graphical or not)
- Havel - Hakimi Theorem (Only Statement)
- Subgraphs- Definition, Examples
- Types of subgraphs
- Vertex deleted subgraphs; Edge deleted subgraphs
- Induced subgraphs
- Spanning Subgraphs
- Complement of Graph and Self Complementary graphs
- Union, Intersection and Product of Graphs
- Fusion of vertices, Decomposition

Unit 2: Connected Graphs	9

- Walk, Trail, Path- Definition, Examples and Properties

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- Connected graphs – Definition and Properties
- Distance between two vertices, Eccentricity, centre, radius and diameter of a graph
- Isthmus, Cut Vertex- Definition, Examples and Properties
- Edge connectivity, Vertex connectivity
- Dijkstra's Algorithm

Unit 3: Eulerian and Hamiltonian Graphs	6

- Konigsberg Bridges Problem
- Eulerian Graphs- Definition, Examples, Necessary and Sufficient Condition (with proof)
- Fleury's Algorithm
- Hamiltonian Graphs- Definition, Examples and Theorems (2 without Proof)
- Chinese Postman Problem, Travelling Salesman Problem

Unit 4: Trees	10

- Definition, Properties of Trees, Theorems
- Centre of a tree
- Spanning tree:
  - o Definition
  - o Properties
  - o Shortest spanning tree- Kruskal's Algorithm, Prim's Algorithm
- Binary Tree – Definition and Properties.
- Tree Traversal
  - o Ordered rooted tree,
  - o Preorder traversal
  - o In order traversal and Post order traversal, Prefix Notation.

Unit 5: Directed Graphs	7

- Definition, Examples, Elementary terminologies and Properties.
- Types of digraphs.
- Connectedness of digraphs.
- Arborescence
- Networks and Flow, MaxFlow-MinCut theorem, Ford Fulkerson Algorithm

Reference Books:

- C. L. Liu, *Elements of Discrete Mathematics*, Tata McGraw Hill, Fourth Edition
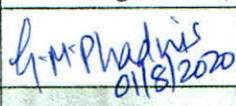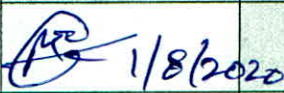- Douglas B. West, *Introduction to Graph Theory*, Pearson Education, Second Edition.
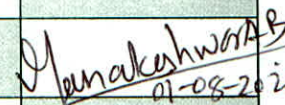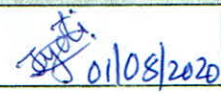
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- Harary, *Graph Theory*, Narosa Publishing House Pvt. Ltd., New Delhi, 2013.
- John Clark and Derek Holton, *A first look at Graph theory*, Allied Publishers.
- Kenneth Rosen, *Discrete Mathematics and its applications*, Tata McGraw Hill, Seventh Edition.
- Narsingh Deo, *Graph Theory with applications to computer science and Engineering*, Prentice Hall.

E-Resources:

- https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=25 for Unit 1 to unit 5
- https://nptel.ac.in
- https://swayam.gov.in

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Subject Expert (Outside SPPU)	Dr. Prashant Malavadkar		01-08-2020
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