SECOND SEMESTER 2020-21
COURSE HANDOUT

Date: 18.01.2021

In addition to part-I (General Handout for all courses appended to the time table) this portion gives further specific details regarding the course.

Course No : MATH F243
Course Title : Graphs and Networks
Instructor-in-Charge : Krishnendra Shekhawat
Instructor(s) :
Tutorial/Practical Instructors: Krishnendra Shekhawat

1. Course Description: This course begins with the basics of Graphs, i.e., it starts with the Simple Graphs and types of Graphs. Then it discusses the Isomorphism in Graphs along with the Euler & Hamiltonian Graphs. After that it talks about Trees and Spanning Trees, Connectivity, Cut Set and Shortest Path, Matrix representation of Graphs, and Maximal Flow in a Network. At the end, it discusses Graph Colouring, Independence number and Chromatic Number.

2. Scope and Objective of the Course: The importance of graph theory can never be exaggerated considering the wide range of its applications, from social sciences to electrical engineering and computer science to management. The rigorous foundation of the subject is thus desirable. The objective of the course is, in addition to logical foundations, theoretical developments and development of the basic skills to tackle problems in Graph theory. It also aimed at understanding how various problems arising from real life or sciences as well as recreational puzzles can be converted to graph theoretic problems like shortest paths, network flows, chromatic numbers, connectivity etc.

3. Text Book: G. Agnarsson and R. Greenlaw, *Graph Theory Modeling, Applications and Algorithms*, Pearson Education, 2007.

4. Reference Books:

R1 Gary Chartrand and Ortrud R. Oellermann, *Applied and Algorithmic Graph Theory*, McGRAW-HILL International Editions, 1993.

R2 Narsingh Deo, *Graph theory with applications to engineering and computer science*, PHI 1993.

R3 Douglas B. West, *Introduction to Graph Theory*, Pearson Education India, 2015.

R4 Gary Chartrand and Ping Zhang, *Introduction to Graph Theory*, Tata McGRAW-HILL Edition 2006.

5. Course Plan:

Module No.	Lecture Session	Reference (Sections)	Learning outcomes
1. Introduction to Graphs	**L1** History of Graph Theory and its Applications	1.1 to 1.3	Familiarize with the history and basic concepts of Graph Theory
	L2 Definitions of Graphs, Degree and Regular Graphs, Degree Sequence, Havel Hakimi Theorem	1.4 to 1.6 (1.5 of R1)	
	L3 Subgraphs, Complete Graphs, Bipartite graphs, Directed Graphs	1.7 to 1.9	
2. Connected Graphs and Graph Isomorphism	**L4-L5** Path and Cycles, Connected Graphs, Strongly Connected Digraphs, Cut Vertex, Cut Edge	2.1, 2.2, 2.7	Introduction to the Connected Graphs and related properties, along with the Isomorphism of Graphs
	L6-L7 Isomorphism of Graphs, Graph Operations	2.3 to 2.6	
3. Graph Trees	**L8** Tree and its equivalent definitions	3.1, 3.2	Familiarize with the concept of (Graph) Tree along with some particular classes of Trees
	L9 Distance, Radius, Diameter, Eccentricity, Centre	3.5	
	L10 Rooted Trees, Binary Trees	3.6 to 3.8	
4. Spanning Trees	**L11-L12** Spanning Trees and Forests in Graphs, Adjacency and Incidence Matrix	4.1 to 4.5	Familiarize with the concept of Spanning Trees and with the Matrix representation of Graphs
	L13 Counting of Spanning Trees, Minimal Spanning Trees	4.6, 4.7	
5. Graph Algorithms	**L14- L15** BFS and DFS Algorithms, Dijkstra's Shortest Path Algorithm	13.4, 13.5, 13.7	Introduction to some of the well known Graph Algorithms
6. Eulerian and Hamiltonian Graphs	**L16-L19** Eulerian and Hamiltonian Graphs, Related Algorithms, Travelling Salesman Problem	5.2 to 5.5	Learn about some more Fundamental Properties of Graphs and related Algorithms
7. Connectivity and Flow	**L20-L21** Cut Set, Edge and Vertex Connectivity, Separable and Non-Separable Graphs	6.1 to 6.3	Introduction to the Connectivity of Graphs and to the concept of Network Flow along with its Applications
	L22-L25 Network Flows, Minimum cut, Menger's Theorem	6.4, 6.5	
8. Planar Graphs	**L26-L29** Planar Embeddings, Euler's Formula, Kuratowaski Theorem, Testing Planarity	7.1 to 7.5	Introduction to the Planar Graphs along with the necessary and sufficient conditions for checking Planarity
	L30 Dual of a Graph, Crossing Number	7.6, 7.9	
9. Graph Coloring	**L31-L35** Bipartite and Multipartite graphs, Chromatic Number, Bounds on Chromatic Numbers, Chromatic Partition, Planar Map Coloring and Four-Color Theorem	Sections 8.1 to 8.4	Familiarize with the concept of Graph Coloring along with Chromatic number and well-known Four-Color Theorem

10. Matchings	**L36-L38** Independence and Domination of Vertices, Vertex and Edge Coverings, Independence Number, Dominance Number, Edge Covering Number	10.1, 10.2, 11.1	Familiarize with the Independence number, Dominance number and Matchings along with its applications
	L39-L40 Matchings, Matching in Bipartite Graphs , Matching Number	10.3, 10.4	

6. Evaluation Scheme:

Component	Duration	Weightage (%)	Date & Time	Nature of component (Close Book/ Open Book)
Mid Term Test	90 min.	35%	TBA	Open Book
Quizzes		20%	TBA	Open Book
Compre. Exam.	3 hrs.	45%	TBA	Open Book

7. Chamber Consultation Hour: To be announced in the class.

8. Notices: NALANDA web-site would be used to post course material as well as notices.

9. Makeup: Prior permission is needed for makeup; makeup will only be given if sufficient evidence is available for not being able to appear for Quizzes/Midsem/Compre.

10. Note (if any):

Krishnendra Shekhawat
Instructor-in-charge
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