NATIONAL INSTITUTE OF TECHNOLOGY: TIRUCHIRAPPALLI- 620 015

DEPARTMENT OF MATHEMATICS

COURSE OUTLINE TEMPLATE			
Course Title	**Graph Theory**		
Course Code	**MA721**	**No. of Credits**	**3**
Department	**Mathematics**	**Course: M. Sc. Branch: Mathematics**	
Pre-requisites Course Code	**Can be done independently**		
Course Coordinator(s) (if, applicable)	**Dr. T.N.Janakiraman**		

Other Course Teacher(s)/Tutor(s)	**Email Id**	**Telephone No.**
Dr. T.N.JANAKIRAMAN	**janaki@nitt.edu**	**9894794198(Personal) 3669(Intercom) 9489066245(official)**
Session	**January 2023**	
Course Type	☐ **Core course**	√ **Elective course**

COURSE OVERVIEW

- **To have general awareness and understanding of**
  - **(1) Various properties some applicable concepts in Graph Theory, which is a pure and applied branch of Mathematics**
  - **(2) Sequential algorithms for the concepts introduced in the course with time complexity to understand the nature in the implementation of the concepts in general**
- **To understand various applications of the introduced concepts in Discrete structures and apply them as a tool to general network problems and other problems.**

COURSE OBJECTIVES

- **To make the students to understand very well about the proof techniques related to the mathematical logic and reasoning in framing various types of solutions for the general problems.**
- **To train students with mathematical and algorithmic aspects so that students will be able to design the expected model network, analyse the structure of the design and able**

to give algorithm to solve for either approximate or exact solution for some related real time problems.	
COURSE OUTCOMES (CO)	
Course Outcomes	**Aligned Programme Outcomes (PO)**
1. To model the given network problems to the related graph theoretic problems, identify the concepts learnt in graph theory, apply them in the problems and try to solve them for possible solution. **2. To decide the nature of the general problem related to network, whether to try for exact or approximate solution for it.** **3. To have knowledge about algorithmic procedure related to the concepts in discrete structures and their properties and using that solve general network real time problems with either approximate or exact solution depending on nature of them.** **4. To be familiar with the mathematical ability to analyze complex network structures by dividing them into various types of clusters..** **5. To be familiar in ranking the members/clusters participating in a group/network.**	**The engineering/Science post graduates will apply their knowledge of logic and reasoning in mathematics to engineering/industrial/ management advanced problems.**

COURSE TEACHING AND LEARNING ACTIVITIES

S.No.	Week	Topic	Mode of Delivery
	Week- 1 **Week - 2**	**1. Introduction to Graph Theory and its applications.(Two Sessions)** **2. Various types of graphs and some basic definitions and examples.** **3. Traversals in graphs definitions, examples and their applications.** **4. Definition of complement of a graph, isomorphism in graphs, self-complementary graphs some properties and their applications.** **5. Connectedness, Connectivity and the results and problems related to them (Two sessions).**	**Chalk and Talk**

		6. Properties of trees and their applications.	
	Week-3 Week-4	1. Concept of distance in graphs. Some basic definitions with examples and some properties of distance related parameters and its applications. 2. Eccentricity properties of graphs and their applications(Two Sessions) 3. Some problems related to distance and eccentricity in graph. 4. Spanning trees, Distinct spanning trees in graphs, recurrence relation and related two graph operators. Some examples.Number of spanning trees of some special graphs such as cycle and Complete graphs and some problems of finding number of spanning trees of different classes of graphs.(three sessions) 5. Definition of Bipartite graphs, K-partite graphs and Characterization of bipartite graphs and their applications.	Chalk and Talk
	Week -5	1. Matrix representation of graphs and their uses. Directed Graphs. Some basic definitions and examples. Some analogous problems, results and applications. 2. Connectedness in directed graphs definitions, examples, properties, their applications and some problems on directed graphs. 3. Definition of Euler graph, examples, properties and applications. Nature time complexity 4. Some applications oriented problems on Euler graphs. Definition of Hamilton graphs and Non-Hamilton graphs. Nature of time complexity to identify the difficulty in characterizing this concept.	Chalk and Talk
	Week-6	1. Dirac's Theorem and related results. 2. Closure of graphs definition, example and results related to Hamiltonion and completeness of closure graphs. 3. Chavtal's theorem, proof, its relation to Closure of a graph, examples and its application. 4. Maximal non- Hamiltonion graphs, Degree majorization in graphs, embedding of any non- Hamiltonion graph in Cm,p graph.	Chalk and Talk

	Week-7	**1. Chromatic number of a graph: Definition, examples. Chromatic critical graphs: Properties. Nature of difficulty in computation.(Two Sessions)** **2. Triangle free k-critical graphs. Edge colouring. Properties of edge colouring. Nature of Difficulty in computation. Relation to Vertex colouring with related graph operations.** **3. Definition, examples and applications of planar graphs. Some properties. Some problems.**	
	Week-8 **Week-9**	**1. Some more properties and problems on planar graphs.** **2. Colouring of planar Graphs, Four colour problem and Five colour Theorem.** **3. Continuation of colouring theorem. Defintions of Vertex covering number, vertex independence number, edge covering number, edge independence number and examples.** **4. Relation between them and number of vertices.** **5. Matching: Introduction, Applications, Maximum matching Characterization.** **6. Some results in Perfect matching with applications.** **7. Matching in bipartite. Perfect Matching.** **8. Various tournament digraphs. Some properties of tournaments and applications.**	
	Week-10	**1. Some advanced results on digraphs and their deduction to Tournaments.** **2. Diconnected Tournaments and their properties.** **3. Ranking of tournaments. Special note of ranking in disconnected tournament.** **4. Application of Euler digraphs in computer drum design.**	
	Week-11 **Week-12**	**1. Introduction to graph algorithms and Time complexity measure of algorithms.** **2. BFS algorithm. Implementation. Examples.** **3. Application of BFS and introduction to DFS Algorithm.** **4. DFS implementation. Complexity.** **5. DFS Applications: Paranthesization. Toplogical search, Finding cut vertices, Directed circuits and strong components(Two sessions).** **6. Shortest path Algorithm. Implementation with example. Applications of Shortest path Algorithm.**	

		7. Introduction to Maximum and Minimum Spanning tree. Applications. Prim's algorithm. Implementation.	
	Week-13	1. Algorithm for Kruskal's method. Implentation. 2. Introduction Planarity Algorithm. Some necessary definitions to implement planarity Algorithm. 3. Implementation of planarity algorithm and complexity of algorithm. Introduction to CPM in acyclic digraph. 4. Implementation of CPM algorithm with example and its applications.	
	Week-14 Week-15	1. Introduction to Maximum Flow and Minimum Cut in network. Necessary Theories and examples.(Two sessions) 2. Maximum flow algorithm implantation with examples. 3. Some problems (left over) 4. Introduction to P, NP, NPC, NP Hard Categories. List of concepts already discussed in this course under these categories. Modelling of other problems to Graph problems and hence the analysis of nature of problem category. Need for approximate algorithms and final conclusion.(Two sessions)	

COURSE ASSESSMENT METHODS

S.No.		Week/Date	Duration	% Weightage
1.	Cycle Test –I	7th week	1 Hour and 30 minutes	20%
2.	Cycle Test-II	13th week	1 Hour and 30 minutes	20%
3.	Compensation test	14th week	1 Hour and 30 minutes	20%
4.	Assignments/ Seminar/Mini Project			10%
5.	End Semester Exam	Second week of May 2023	Three hours	50% Total : 100 Marks

ESSENTIAL READINGS : Textbooks, reference books Website addresses, journals, etc.
NOTE: Seminars/Mini project need to be given by all the students on any topic "Applications of Graph theory in any of Science/Engineering/Management branches".

MA721 Graph Theory

UNIT 1

Basic definitions, examples and some results, relating degree, walk, trail, path, tour, cycle, complement of a graph, self-complementary graph, Connectedness, Connectivity, distance, shortest path, radius, diameter and Bipartite graphs. Some eccentric properties of graphs, tree, spanning tree, coding of spanning tree . Number of spanning trees in a complete graph. Recursive procedure to find number of spanning trees. Construction of spanning trees.

UNIT 2

Directed graphs: some standard definitions and examples of strongly, weakly, unilaterally connected digraphs, strong components and deadlock. Matrix representation of graph and digraphs. Some properties (proof not expected). Eulerian graphs and standard results relating to characterization of Eulerian graphs. Hamiltonian graph-standard theorems (Dirac theorem, Chavtal theorem, closure of graph). Non Hamiltonian graph with maximum number of edges. Self-centered graphs and related simple theorems.

UNIT 3

Chromatic number; vertex chromatic number of a graph, edge chromatic number of a graph (only properties and examples)-application to coloring. Planar graphs, Euler's formula, maximum number of edges in a planar graph, some problems related to planarity and non-planarity, Five color theorem, Vertex Covering, Edge Covering, Vertex independence number, Edge independence number, relation between them and number of vertices of a graph.

UNIT 4

Matching theory, maximal matching and algorithms for maximal matching. Perfect matching (only properties and applications to regular graphs). Tournaments, some properties and theorems on digraphs with deduction tp strongly connected tournaments. Application of Eulerian digraphs.

UNIT 5

DFS-BFS algorithms and applications, shortest path algorithm, Min-spanning tree and Max-spanning tree algorithms and their applications, Planarity algorithm. Flows in graphs; Maxflow and min-cut theorem, algorithm for maxflow. PERT-CPM. Bin packing, Knap sack problems and related optimization problems, Complexity of algorithms; P-NP-NPC-NP hard problems and examples.

Text Books:

1. **J.A.Bondy and U.S.R.Murty, Graph Theory with Applications, Macmillan, London (1976) EBook, Freely Downloadable.(One soft copy is also uploaded in the website)**
2. **Cormen, Leiserson, Rivest, and Stein, Introduction to Algorithms (Second edition), McGraw-Hill (2001).**

Reference Books

1. **M.Gondran and M.Minoux: Graphs and Algorithms, John Wiley, 1984.**
2. **H.Gerez: Algorithms for VLSI Design Automation, John Wiley, 1999.**

COURSE EXIT SURVEY (mention the ways in which the feedback about the course is assessed and indicate the attainment also)

Feed back at the end of the course may be given with their rating to

- **(i) The expected use of this course for their project and higher studies;**
- **(ii) The teacher's involvement, capacity, authority and approach to introduce this course in PG level; and**
- **(iii) improve understanding and further applications, need for addition of some new contents and also removal of unrelated topics need to be obtained.**

COURSE POLICY (including plagiarism, academic honesty, attendance, etc.)

1. **Minimum 75% attendance general.**
2. **In genuine case, with medical certificate minimum 65% attendance.**
3. **Cycle test I and II -40 marks each.(Finally forty marks will be converted to maximum 20 marks for each in the internal.)**
4. **Duration cycle each of the cycle tests 1(1/2) hours.**
5. **Seminar/Individual mini project topics must be selected by the students, which must be applications of Graph theory topics (taught in the course) in any field.**

ADDITIONAL COURSE INFORMATION

1. **The e-book is attached which is a bible for all new learners and researchers of this topic.**

FOR SENATE'S CONSIDERATION

Course Faculty :Dr.T.N.Janakiraman	CC-Chairperson	HOD
	25-01-2023	