INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

COMPUTER SCIENCE AND ENGINEERING

QUESTION BANK

Course Title	**COPETITIVE PROGRAMMING USING GRAPH ALGORITHMS**				
Course Code	**ACSC22**				
Program	B. Tech.				
Semester	V				
Course Type	Value Added Course				
Regulations	IARE – UG 20				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	2	-	-	-	-
Chief Coordinator	Dr. Sreedevi S L, Assistant Professor,				

COURSE OBJECTIVES:

The students will try to learn:	
I	Concepts of graph theory along with applications
II	Connected graphs and algorithms for Traversability
III	Directed graphs and planar graphs along with applications

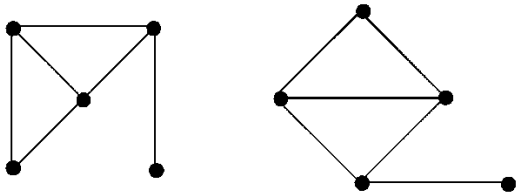
COURSE OUTCOMES:

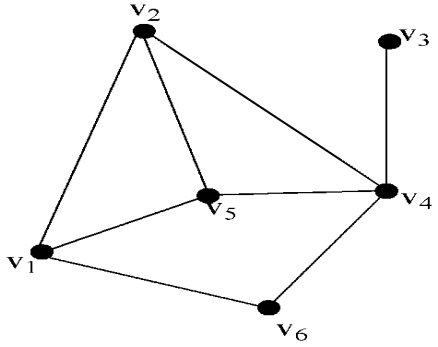
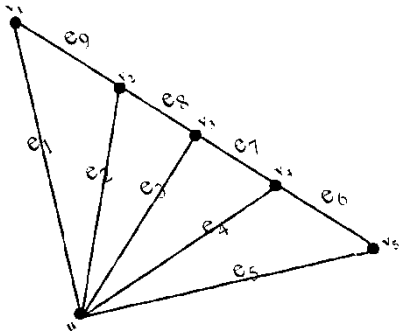
At the end of the course the students should be able to:

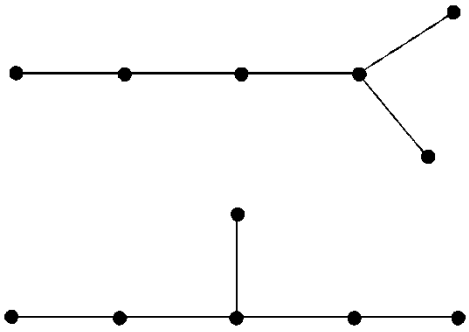
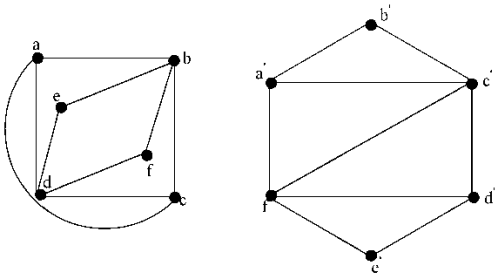
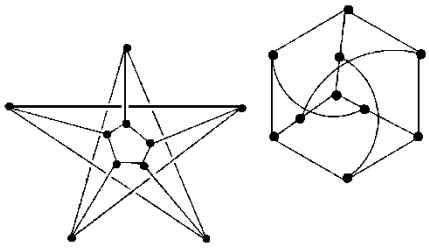
Course Outcomes		**Knowledge Level (Bloom's Taxonomy)**
CO 1	State the definitions of different graphs	Remember
CO 2	Interpret the definitions to answer given problem	Understand
CO 3	Use the knowledge on graphs and the concepts of connectedness, directed graphs and planar graphs to different applications.	Apply
CO 4	Correlate the definitions of graphs studied to analyze the given problem.	Analyze
CO 5	Appraise the situation using the definitions and theorems studied earlier	Evaluate

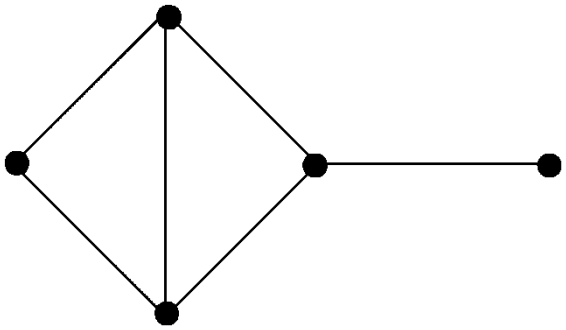
TUTORIAL QUESTION BANK

MODULE – I				
INTRODUCTION TO BUSINESS ENVIRONMENT				
PART - A (SHORT ANSWER QUESTIONS)				
S. No	**QUESTIONS**	**Blooms Taxonomy Level**	**How does this Subsume the level**	**Course Outcome**
1	Define the terminology Graph.	Remember	Learner to recall the basic definitions of graph	CO 01
2	Define the order and size of a graph.	Remember	Learner to recall the basic definitions of graph	CO 01
3	Draw all simple graphs of one, two, three, and four vertices	Remember	Learner to recall the basic definitions of graph	CO 01
4	Give the condition for the adjacency of (i) two vertices (ii) two edges.	Understand	Learner to interpret the basic definitions of graph	CO 02
5	Define a null graph. Draw a null graph of order 4	Remember	Learner to recall the basic definitions of graph	CO 01
6	Define the terms pendant vertex, isolated vertex	Remember	Learner to recall the basic definitions of graph.	CO 01
7	Define the terminologies self loop and multiple edges.	Remember	Learner to recall the basic definitions of graph	CO 01
8	What is meant by pseudo graph and simple graph?	Remember	Learner to recall the basic definitions of graph	CO 01
9	What is a finite graph? Give a finite graph of order 4 and size 8.	Remember	Learner to recall the basic definitions of graph	CO 01
10	Define the adjacency matrix of a graph.	Remember	Learner to recall the basic definitions of graph	CO 01
11	Define the incidence matrix of a graph.	Remember	Learner to recall the basic definitions of graph	CO 01
12	Define complete graph and give a diagrammatic representation of a complete graph of order 5	Remember	Learner to recall the basic definitions of graph	CO 01
13	Define the concepts K_n and C_n.	Remember	Learner to recall the basic definitions of graph	CO 01
14	Define degree of a vertex. What is meant by regular graph?	Remember	Learner to recall the basic definitions of graph	CO 01
15	State handshaking lemma.	Remember	Learner to recall the lemma	CO 01
16	State the relation between the number of edges and total degree of a graph.	Apply	Learner to use hand shaking lemma	CO 03
17	Define the terminology bipartition in a graph.	Remember	Learner to recall the basic definitions of graph	CO 01

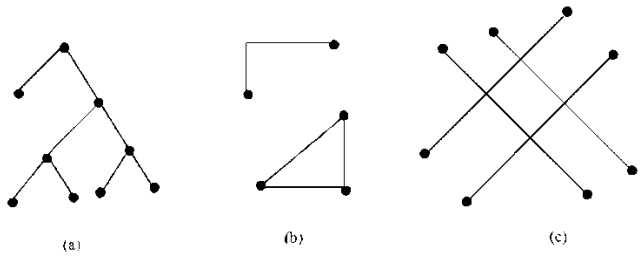
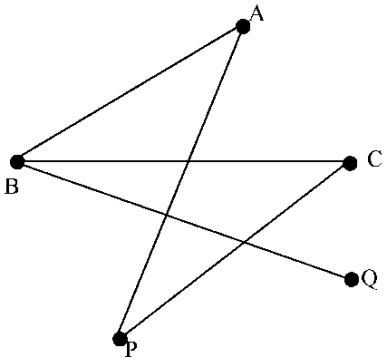
18	What is meant by $K_{m,n}$?	Remember	Learner to recall the basic definitions of graph	CO 01
19	Define labeling of a graph	Remember	Learner to recall the basic definitions of graph	CO 01
20	Define isomorphism of two graphs G_1 and G_2	Remember	Learner to recall the basic definitions of graph	CO 01
21	Are the given graphs isomorphic? 	Apply	Learner to use the knowledge of isomorphic graphs	CO 03
22	State the basic conditions that are required to check for isomorphism of two graphs.	Remember	Learner to recall the basic definitions of graph	CO 01
23	Define the complement of a graph with a simple illustration.	Remember	Learner to recall the basic definitions of graph	CO 01
24	Comment on the complement of complete graph and that of $K_{m,n}$	Analyze	Learner to correlate the definition of complement of a graph	CO 04
25	Define the union of two graphs G_1 and G_2, with a simple illustration	Remember	Learner to recall the basic definitions of graph	CO 01
26	Define the ring sum of two graphs G_1 and G_2, with a simple illustration	Remember	Learner to recall the basic definitions of graph	CO 01
27	What is meant by deletion of a vertex? How does it affect the order and size of graph?	Apply	Learner to use the definition of vertex deletion of a graph	CO 03
28	What is meant by deletion of an edge? What is its effect on the order and size of graph?	Apply	Learner to use the definition of edge deletion of a graph	CO 03
29	Define the intersection of two graphs G_1 and G_2, with a simple illustration	Remember	Learner to recall the basic definitions of graph	CO 01
30	Who is called as father of Graph Theory? Why he is called so?	Remember	Learner to recall the general discussion in class	CO 01
PART - B (LONG ANSWER QUESTIONS)				
1	Draw all six non isomorphic simple graphs with five vertices and five edges	Remember	Learner to recall the basic definitions of graph	CO 01
2	Draw graphs representing problems of connecting (a) two houses and three utilities;(b) four houses and four utilities,(Use $H_i's$ for houses and $U_i's$ for utilities)	Understand	Learner to interpret the definitions of adjacency of vertices	CO 02

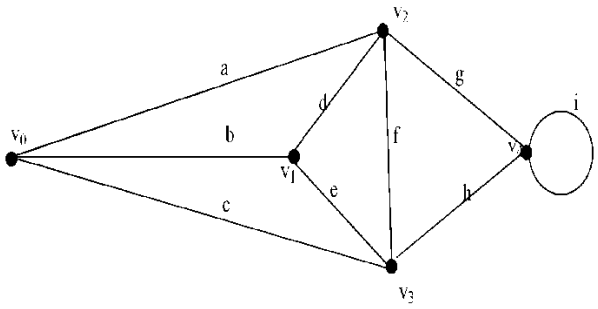
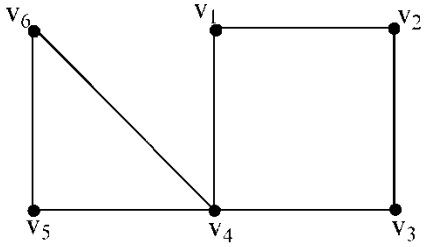
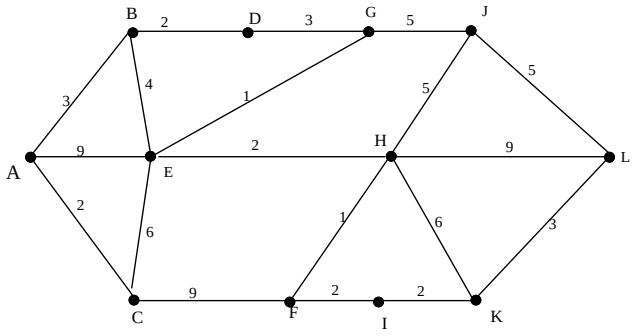
3	Name 2 situations (games, activities, real-life problems, etc.) that can be represented by means of graphs. Explain what the vertices and the edges denote.	Apply	Learner to use the definitions of graph to real time application	CO 03
4	Justify that an infinite graph with a finite number of edges must have an infinite number of isolated vertices.	Analyze	Learner to correlate the definitions of graph	CO 04
5	Show that an infinite graph with a finite number of vertices will have at least one pair of vertices or one vertex joined by an infinite number of parallel edges.	Analyze	Learner to correlate the definitions of graph	CO 04
6	Show that the maximum degree of any vertex in a simple graph with n vertices is $n - 1$.	Analyze	Learner to correlate the definitions of graph	CO 04
7	Show that the maximum number of edges in a simple graph with n vertices is $n\ (n - 1)/2$.	Analyze	Learner to correlate the definitions of graph	CO 04
8	What is meant by the terms sub graph and induced sub graph of a graph. Explain in detail with a graph of order 5 and size 8.	Apply	Learner to use the basic definitions of graph	CO 03
9	How do you define the Adjacency matrix of a graph of order n and size m. Write down the adjacency matrix of the given graph. 	Apply	Learner to use the definitions of Matrix of a graph	CO 03
10	How to define the incidence matrix of a graph? Write down the incidence matrix for the graph shown here: 	Apply	Learner to use the definitions of Matrix of a given graph	CO 03
11	Explain the terminologies complete graph and connected graph. Is every connected graph a complete graph? Illustrate with a simple example.	Analyze	Learner to correlate the definitions of graph	CO 04

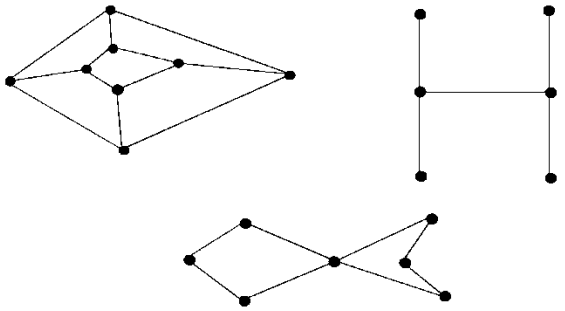
12	Draw a 3 regular graph of order 6, which is (i) simple graph (ii) pseudo graph.	Apply	Learner to use the definitions of graph	CO 03
13	Construct a 3 regular graph on 10 vertices	Apply	Learner to use the definitions of graph	CO 03
14	Discuss the properties of Petersen graph. Give any two isomorphic representations of Petersen graph.	Apply	Learner to use the definitions of graph	CO 03
15	What is meant by bipartite graph and a complete bipartite graph. Give illustrations.	Apply	Learner to use the definitions of graph	CO 03
16	State handshaking lemma. Show that the number of vertices of odd degree in a graph is always even.	Apply	Learner to use the definitions of graph	CO 03
17	Explain the terminology partitioning of a graph. Give one real life application	Apply	Learner to use the definitions of graph	CO 03
18	Test for the isomorphism of given graphs with suitable labeling. 	Apply	Learner to use the definitions of isomorphism of graph	CO 03
19	Are the graphs isomorphic? Give reason 	Analyze	Learner to correlate the definitions of isomorphic graph	CO 04
20	Test for the isomorphism of given graphs with suitable labeling. 	Apply	Learner to use the definitions of isomorphism graph	CO 03
21	What is meant by self complementary graph? Give any two examples of smallest nontrivial self complementary graphs.	Apply	Learner to use the definitions of graph	CO 03
22	Construct 3 non-isomorphic spanning sub graphs of the given graph	Apply	Learner to use the definitions of graph	CO 03

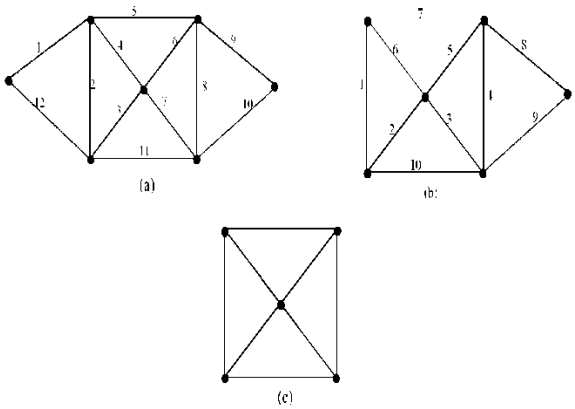
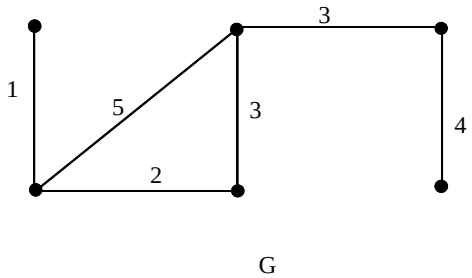
				
23	How to explain the binary operation of Cartesian product of two graphs.	Remember	Learner to recall the definitions on graph operations	CO 01
24	Explain the Composition of two graphs G_1 and G_2.	Remember	Learner to recall the definitions on graph operations	CO 01
25	Find the Cartesian product of K_3 and K_2.	Apply	Learner to use the definitions of graph	CO 03
PART - C (PROBLEM SOLVING AND CRITICAL THINKING QUESTIONS)				
1	Briefly discuss Konigsberg bridge problem with neat diagram. Why it is not possible to have such a tour.	Analyze	Learner to correlate the definitions of graph	CO 04
2	Define complement of a graph. Comment on the size of (i) complement of complete graph (ii) cycle. Prove or disprove that complement of a simple disconnected graph must be connected.	Apply	Learner to use the definitions of graph	CO 03
3	What is the size of an r-regular graph of order p? Does a 3-regular graph on 14 vertices exist? What you can comment on 17 vertices?	Analyze	Learner to correlate the definitions to evaluate	CO 04
4	Draw K_6 giving labeling for vertices and edges. From your figure find any (i) 3 non isomorphic sub graphs (ii) 2 induced sub graphs and (iii) 1 clique	Apply	Learner to use the definitions of graph	CO 03
5	Comment on the deletion of a vertex and deletion of an edge. Discuss the effect of a vertex deletion on the order and size of graph. What effect does an edge deletion makes on the graph? Illustrate with a example.	Apply	Learner to use the definitions of graph	CO 03

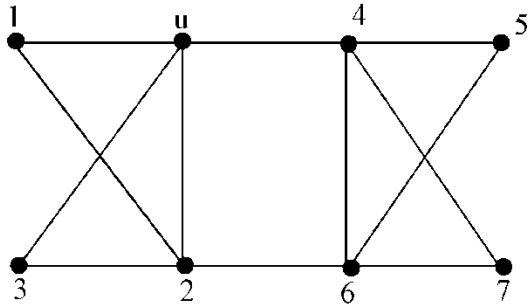
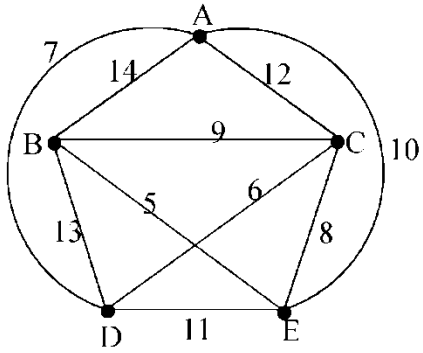
MODULE – II				
CONNECTED GRAPHS AND SHORTEST PATHS				
PART – A (SHORT ANSWER QUESTIONS)				
1	Define the terminology Walk in a graph.	Remember	Learner to recall the definition	CO 01
2	Define the terminology Trail.	Remember	Learner to recall the definition	CO 01
3	Define the terminology Path.	Remember	Learner to recall the definition	CO 01
4	What is meant by a Cycle?	Remember	Learner to recall the definition	CO 01
5	Define the terms initial and terminal vertices of a path.	Understand	Learner to interpret the definition	CO 02
6	Define the length of a path.	Remember	Learner to recall the definition	CO 01
7	Neatly sketch a path and a cycle of 4 vertices each.	Understand	Learner to interpret the definition	CO 02
8	Define the distance between two vertices of a graph.	Remember	Learner to recall the definition	CO 01
9	Define a disconnected graph, with one example.	Remember	Learner to recall the definition	CO 01
10	What is meant by the components of a graph?	Remember	Learner to recall the definition	CO 01
11	Define disconnecting set in a graph	Remember	Learner to recall the definition	CO 01
12	Define the term cut vertex in a graph.	Remember	Learner to recall the definition	CO 01
13	What is denoted by $\boldsymbol{\lambda(G)}$?	Remember	Learner to recall the definition	CO 01
14	What is meant by the terminology bridge in a graph?	Remember	Learner to recall the definition	CO 01
15	Define a separable graph.	Remember	Learner to recall the definition	CO 01
16	What is meant by a block?	Remember	Learner to recall the definition	CO 01
17	Define the terminology girth.	Remember	Learner to recall the definition	CO 01
18	Define diameter of a graph. What is the diameter of Petersen graph?	Understand	Learner to interpret the definition	CO 02
19	What is meant by a weighted graph?	Remember	Learner to recall the definition	CO 01
20	Give one situation where weighted graphs are being used.	Understand	Learner to interpret the definition	CO 02

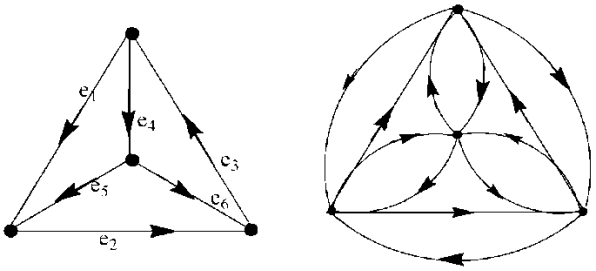
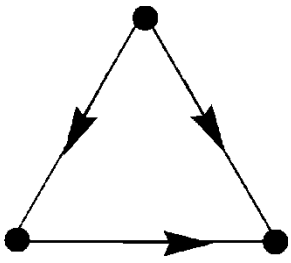
PART – B (LONG ANSWER QUESTIONS)				
1	What is meant by (i) cycle and (ii) path? Give illustrations of both with 5 vertices each.	Remember	Learner to recall the definition	CO 01
2	Draw a connected graph, which becomes disconnected when, (i) a vertex is removed from it. (ii) an edge is removed from it	Apply	Learner to use the definition	CO 03
3	Justify that a connected graph G remains connected after removing an edge e from G, if and only if e is in some circuit in G.	Analyze	Learner to correlate definition	CO 04
4	Which of the following given graphs are connected. Give explanation for each figure (stating properly the order, size and $\omega(G)$)  	Apply	Learner to use the definition	CO 03
5	If a graph (connected or disconnected) has exactly two vertices of odd degree, there must be a path joining these two vertices.	Analyze	Learner to correlate the definition	CO 04
6	Consider the graph and find the nature of sequence (i) BAPCB (ii) PABQ (iii) CBAPCBQ  	Apply	Learner to use the definition	CO 03
7	State the difference between disconnecting set and cut set.	Understand	Learner to interpret the definition	CO 02
8	Explain the terms cut edges and edge connectivity. Support your explanation with a neat figure.	Apply	Learner to use the definition	CO 03
9	Explain the difference between the terms cut vertices and articulation point, with the help of a diagram.	Remember	Learner to recall the definition	CO 01
10	Explain in detail block in a graph with a suitable diagram.	Understand	Learner to interpret the definition	CO 02

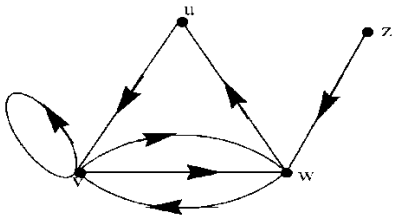
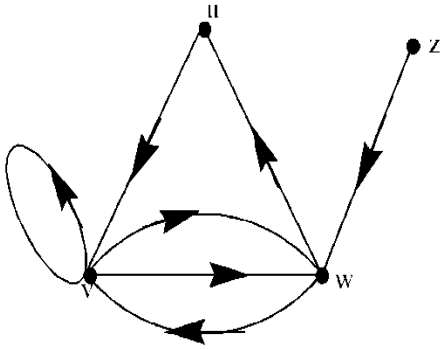
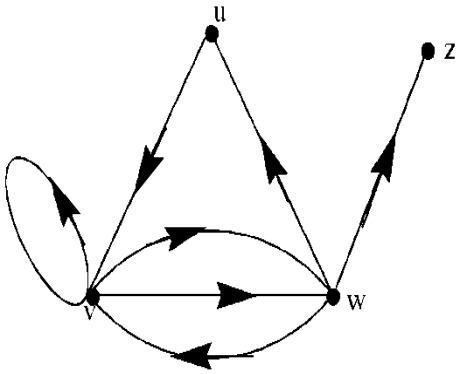
PART – C (PROBLEM SOLVING AND CRITICAL THINKING)				
1	From the given graph write down (i) list any 4 different paths between vertices v_0 and v_2. (ii) list any 4 different cycles .(iii) Any 2 edge disjoint cycles. 	Understand	Learner to interpret the definition	CO 02
2	If intersection of two paths is a disconnected graph, show that union of two paths has at least one circuit.	Analyze	Learner to correlate the definition	CO 04
3	Show that if a connected graph G is decomposed into two sub graphs G_1 and G_2, there must be at least one vertex common between G_1 and G_2.	Apply	Learner to use the definition	CO 03
4	For the graph given below indicate the nature of following sequences of vertices. (i)$v_6v_5v_4v_3v_2v_1v_4v_6$ (ii)$v_4v_1v_2v_3v_4v_5$ (iii) $v_1v_2v_3v_4v_5$ (iv) $v_1v_2v_3v_4v_1$ (v) $v_1v_6v_5v_4v_3$ 	Analyze	Learner to correlate the learned concepts	CO 04
5	Find the shortest path between the points A and L given in the figure. 	Evaluate	Learner to appraise the situation using learned concepts	CO 05

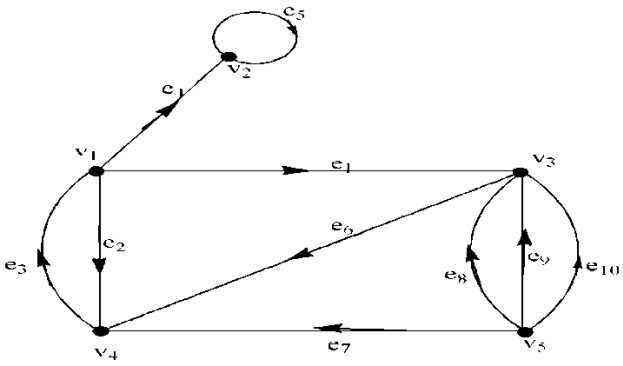
MODULE-III				
TRAVERSABILITY				
PART - A (SHORT ANSWER QUESTIONS)				
1	Define the terminology Eulerian graph.	Remember	Learner to recall the definition	CO 01
2	Define Eulerian trail in a graph.	Remember	Learner to recall the definition	CO 01
3	Explain the terminology Semi- Eulerian trail.	Remember	Learner to recall the definition	CO 01
4	What is a Unicursal graph?	Remember	Learner to recall the definition	CO 01
5	Define Hamiltonian circuit in a graph.	Remember	Learner to recall the definition	CO 01
6	Comment on the relation between number of edges and vertices in a Hamiltonian circuit.	Understand	Learner to use definition	CO 02
7	State Diarc's theorem.	Remember	Learner to recall the theorem Statement	CO 01
8	Briefly explain travelling salesman problem.	Remember	Learner to recall the definition	CO 01
9	Explain Chinese Postman Problem	Remember	Learner to recall the definition	CO 01
10	Which all graphs are Hamiltonian: 	Apply	Learner to use the knowledge of definition	CO 03
11	Define graph theoretically the concept of tree.	Remember	Learner to recall the definition	CO 01
12	Draw all possible trees with 2 vertices, 3 vertices and 5 vertices.	Apply	Learner to use the knowledge of definition	CO 03
13	Graph theoretically what is meant by a forest?	Remember	Learner to recall the definition	CO 01
14	Define a spanning tree of a graph.	Remember	Learner to recall the definition	CO 01
15	Define a rooted tree in a graph.	Remember	Learner to recall the definition	CO 01
16	Give one application area of binary trees.	Apply	Learner to use the knowledge of definition	CO 03
17	Define a branch and chord in a spanning tree.	Remember	Learner to recall the definition	CO 01

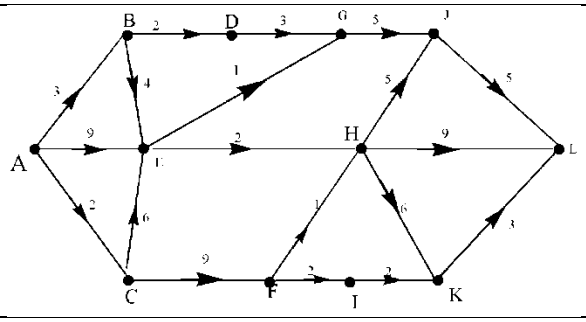
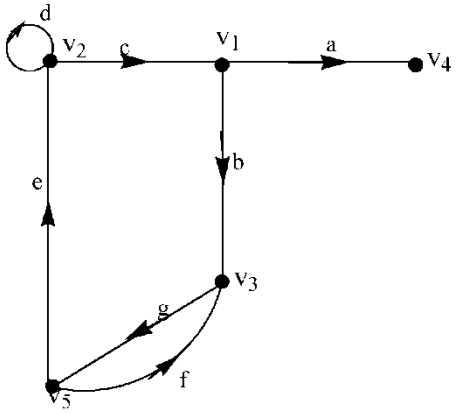
18	Define the term eccentricity of a vertex.	Remember	Learner to recall the definition	CO 01
19	Define the terminology leaf in a tree.	Remember	Learner to recall the definition	CO 01
20	What is meant by height of a tree?	Remember	Learner to recall the definition	CO 01
PART – B (LONG ANSWER QUESTIONS)				
1	Classify the given graphs into Eulerian/ Semi Eulerian/ Non- Eulerian 	Apply	Learner to use the knowledge of definition	CO 03
2	Justify that a connected Graph G is Eulerian, if and only if the degree of each vertex of G is even**.**	Analyze	Learner to correlate the definition	CO 04
3	If given graph G is Eulerian, can you assert that G is connected? Comment on the isolated vertices of G, if it has	Analyze	Learner to correlate the definition	CO 04
4	Explain arbitrarily traceable graph from a vertex v, with an example.	Apply	Learner to use the knowledge of definition	CO 03
5	Give one example and counter example for arbitrarily traceable graphs.	Apply	Learner to use the knowledge of definition	CO 03
6	State Diarc's theorem. Give an example to show that Diarc's theorem is not necessary for a graph to be Hamiltonian?	Apply	Learner to use the theorem and knowledge of Hamiltonian circuits.	CO 03
7	State any three equivalent properties of a tree.	Remember	Learner to recall the definition	CO 01
8	What is minimal spanning tree? Explain in detail with the help of given graph G.  G	Apply	Learner to use the definition	CO 03

9	Explain the terms center and centroids of a tree. Support your explanation with a diagram.	Remember	Learner to recall the definition	CO 01
10	State Cayley's theorem for labeled trees. Draw all labeled trees of 3 vertices.	Apply	Learner to use the knowledge on trees	CO 03
PART – C (PROBLEM SOLVING AND CRITICAL THINKING)				
1	Justify that a connected Graph G is Eulerian, if and only if the degree of each vertex of G is even. Give an example to show that if degree of each vertex is odd, then the graph is not Eulerian.	Apply	Learner to use the knowledge of Euler Graph	CO 03
2	Explain Fleury's algorithm and apply Fluery's Algorithm to the graph given below from the vertex u to find out an Eulerian tour. 	Analyze	Learner to correlate Fleury's Algorithm to find out Eulerian tour	CO 04
3	Identify the following graphs as Eulerian/ Semi-Eulerian/ Non- Eulerian. (i) K_5, (ii) $K_{2,3}$, (iii) Graph of Cube, (iv) Petersen Graph.	Apply	Learner to use the concepts of Eulerian/ Semi-Eulerian/ Non- Eulerian.	CO 03
4	Find the minimum Hamiltonian circuit starting from node E in the given graph. 	Evaluate	Learner to appraise the concept of minimum Hamiltonian circuit	CO 05
5	What is the difference between a binary tree and a complete binary tree? Give examples.	Analyze	Learner to correlate the definitions	CO 04
MODULE-IV				
DIRECTED GRAPHS				
PART – A (SHORT ANSWER QUESTIONS)				
1	Define the terminology directed graph.	Remember	Learner has to recall the definition	CO 01

2	What is meant by underlying graph of a digraph?	Understand	Learner has to interpret the definition	CO 02
3	How do you define a simple digraph?	Remember	Learner has to recall the definition	CO 01
4	Define initial vertex in a digraph.	Remember	Learner has to recall the definition	CO 01
5	Define the terminology tail vertex.	Remember	Learner has to recall the definition	CO 01
6	What is meant by terminal vertex in a digraph?	Remember	Learner has to recall the definition	CO 01
7	Which of the given digraphs are simple? 	Understand	Learner has to interpret the definition	CO 02
8	Define oriented graph, with a diagrammatic representation.	Remember	Learner has to recall the definition	CO 01
9	Is any Eulerian graph orientable? Why?	Analyze	Learner has to correlate the definition	CO 04
10	Define a balanced digraph, with an example	Remember	Learner has to recall the definition	CO 01
11	Discuss critical path problem.	Remember	Learner has to recall the definition	CO 01
12	Comment on source and sink of an Eulerian digraph.	Apply	Learner has to use the knowledge of terminologies asked here	CO 03
13	Define source and sink in a digraph.	Remember	Learner has to recall the definition	CO 01
14	Will a directed graph be always Eulerian if its underlying graph is Eulerian? Justify your answer.	Apply	Learner has to use the knowledge of terminologies asked here	CO 03
15	Define the concept Hamiltonian digraph.	Remember	Learner has to recall the definition	CO 01
16	Is the given digraph Eulerian? 	Analyze	Learner has to correlate the definition	CO 04
17	Define the concept Eulerian digraph.	Remember	Learner has to recall the definition	CO 01
18	Define directed tree. Give any 2 applications.	Remember	Learner has to recall the definition	CO 01
19	Define arborescence in a digraph.	Remember	Learner has to recall the definition	CO 01

20	Comment on topological sorting.	Remember	Learner has to recall the definition	CO 01
PART – B (LONG ANSWER QUESTIONS)				
1	Consider the figure given, write down the vertices and directed edges 	Understand	Learner has to interpret the knowledge of terminologies asked here	CO 02
2	Is it always required that the underlying graph of simple digraph is always simple? Give an example to support your claim.	Apply	Learner has to use the knowledge of terminologies asked here	CO 03
3	Test for isomorphism for the following directed graphs. Justify your answer.  	Analyze	Learner has to correlate the definition	CO 04

4	What is the relation between sum of in-degrees and out-degrees in a directed graph with the number of edges? Verify your answer with the directed graph given below:  Directed graph with 5 vertices	Analyze	Learner has to correlate the definition	CO 04
5	What is meant by a tournament? Mention the applications of tournament.	Apply	Learner has to use the knowledge of terminologies asked here	CO 03
6	Explain the terminology orientable graph. Give an example of orientable graph.	Remember	Learner has to recall the definition	CO 01
7	What is the difference between trial and a directed trail? Explain in detail with an example.	Apply	Learner has to use the knowledge of terminologies asked here	CO 03
8	Can every acyclic digraph be a tree? Justify your answer with a diagram.	Analyze	Learner has to correlate the definition	CO 04
9	Explain the adjacency matrix of a directed graph.	Remember	Learner has to recall the definition	CO 01
10	Explain incidence matrix of a directed graph.	Remember	Learner has to recall the definition	CO 01
PART – C (PROBLEM SOLVING AND CRITICAL THINKING)				
1	Explain a complete digraph. What are the two types of complete digraphs? Explain in detail with figures.	Remember	Learner has to recall the definition	CO 01
2	What is meant by the concept of connectedness in a digraph. Explain strongly connected, unilaterally connected and weakly connected digraphs.	Remember	Learner has to recall the definition	CO 01
3	Using critical path problem solve the activity shown in graph where vertices A and L denotes the beginning and ending of the activity.	Evaluate	Learner has to appraise the situation according to learned concepts	CO 05

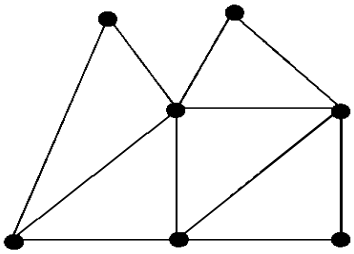
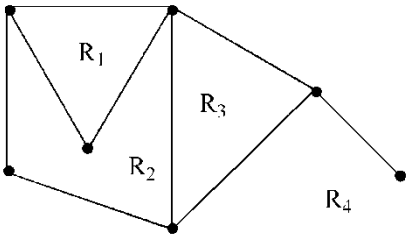
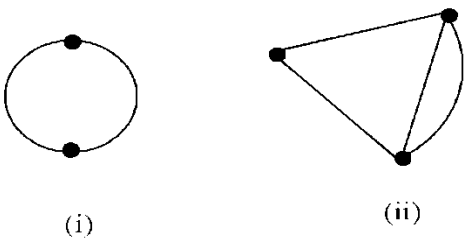
				
4	Explain the terminology arborescence. What is a spanning arborescence? Find a spanning arborescence with respect to the given tree. 	Apply	Learner has to use the knowledge of terminologies asked here	CO 03
5	Explain the terminology topological sorting in a digraph. Give the algorithm to carry out topological sorting. Give one application area of topological sorting.	Remember	Learner has to recall the definition	CO 01

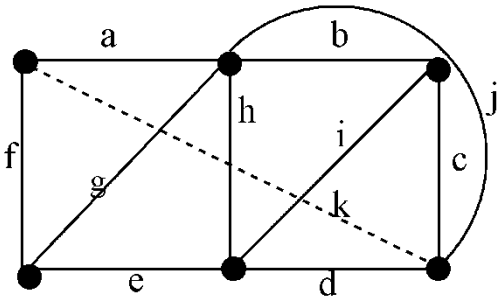
MODULE-V

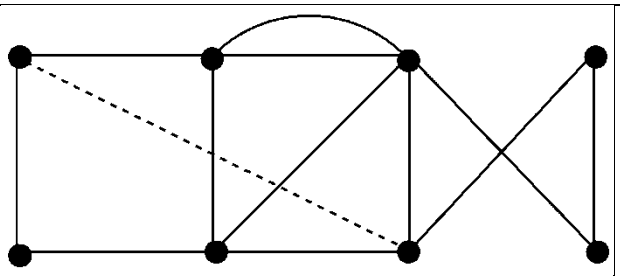
PLANARITY

PART – A (SHORT ANSWER QUESTIONS)

1	Define a the terminology planar graph.	Remember	Learner has to recall the definition	CO 01
2	What is meant by embedding of a graph?	Understand	Learner has to interpret definition	CO 02
3	Define non planar graphs, with an example.	Remember	Learner has to recall the definition	CO 01
4	Show, by drawing, that the bipartite graphs $K_{2,4}$ and $K_{2,2}$ are planar.	Apply	Learner has to use the knowledge of terminologies asked here	CO 03
5	Explain Kuratowski's first and second graph.	Remember	Learner has to recall the definition	CO 01
6	Define outer planar graph giving a simple example.	Remember	Learner has to recall the definition	CO 01
7	Define the concept of region in a plane graph.	Remember	Learner has to recall the definition	CO 01

8	Define the degree of a region.	Remember	Learner has to recall the definition	CO 01
9	Give the relation between degree of a region and number of edges of a planar graph.	Apply	Learner has to use the knowledge of terminologies asked here	CO 03
10	State Euler's fundamental theorem on planar graph.	Remember	Learner has to recall the theorem	CO 01
11	Verify Euler's formula for the given graph. 	Apply	Learner has to use the knowledge of Euler's formula	CO 03
12	What is meant by maximal planar graph? Give an example.	Remember	Learner has to recall the definition	CO 01
13	State the condition for the existence of the dual of a graph.	Understand	Learner has to interpret definition	CO 02
14	Define the terminology crossing number.	Remember	Learner has to recall the definition	CO 01
15	What is the crossing number of a planar graph?	Remember	Learner has to recall the definition	CO 01
16	Define the concept self dual of a planar graph.	Remember	Learner has to recall the definition	CO 01
17	Find the degree of regions and verify that sum of degrees is equal to twice the number of edges. 	Apply	Learner has to use the knowledge of terminologies asked here	CO 03
18	Show that following graphs are self dual. 	Apply	Learner has to use the knowledge of terminologies asked here	CO 03
19	State five color theorem.	Remember	Learner has to recall the definition	CO 01
20	State four color theorem.	Remember	Learner has to recall the definition	CO 01
	PART - B (LONG ANSWER QUESTIONS)			
1	Show that, 'the complete graph of five vertices is non planar'.	Apply	Learner has to use the knowledge of terminologies	CO 03

			asked here	
2	If there are five houses and two utilities, is it possible to join each house to each outlet in such a way that no two lines of joining cross each other?	Apply	Learner has to use the knowledge on planarity	CO 03
3	Three unfriendly neighbours use the same water, oil and treacle wells. In order to avoid meeting, they wish to build non- crossing paths from each of their houses to each of the three wells. Can this be done?	Apply	Learner has to use the knowledge on planar embedding	CO 03
4	What is the maximum value of n,m $(n, m \in \mathbb{N})$, complete graphs and complete bipartite graphs are planar?	Apply	Learner has to use the knowledge on planarity	CO 03
5	Define outer planar graph. Show that K_4 and $K_{2,3}$ is not outer planar.	Analyze	Learner has to correlate the knowledge on outer planarity	CO 04
6	Prove that K_5 is non planar graph with smallest number of vertices.	Apply	Learner has to use the knowledge on planarity	CO 03
7	Prove that $K_{3,3}$ is non planar graph with smallest number of edges.	Apply	Learner has to use the knowledge on planarity	CO 03
8	Using Euler's formula show that K_5 and $K_{3,3}$ are non planar.	Apply	Learner has to use the knowledge on Euler's formula	CO 03
9	State Tait's conjecture.	Remember	Learner has to recall the conjecture	CO 01
10	What is meant by dual of a planar graph?	Understand	Learner has to interpret definition	CO 02
PART – C (PROBLEM SOLVING AND CRITICAL THINKING)				
1	Show that the given graph is planar, by drawing an isomorphic plane graph with straight edges. Label the regions defined by your plane graph and list the edges which form the boundary of each region. 	Apply	Learner has to use the knowledge of terminologies asked here	CO 03
2	State Kuratowski's theorem on planarity of graph. Show that K_5 and $K_{3,3}$ are non planar.	Apply	Learner has to use the knowledge on Kuratowski's theorem	CO 02
3	Discuss elementary reduction. By using elementary reduction, show that the following graph is planar.	Apply	Learner has to use the knowledge on elementary reduction	CO 02

				
4	Give Euler's formula for a connected planar graph. Show that in any connected simple planar graph G with n vertices e edges and r regions, (i) $e \geq \frac{3}{2}r$ (ii) $e \leq 3n-6$ (iii) if G is triangle free, then show that, $e \leq 2n-4$.	Evaluate	Learner has to use the knowledge of Euler's to evaluate the remaining formulas	CO 05
5	If every region of a simple planar graph with n-vertices and e-edges are embedded in a plane is bounded by k-edges then show that $e = \frac{k(n-1)}{k-2}$	Evaluate	Learner has to use the knowledge of Euler's to evaluate the formula	CO 05

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