International Islamic University Chittagong

Department of Computer Science and Engineering

B. Sc. in CSE Final Examination, Spring 2018

Course Code: CSE 2403 Course Title: Computer Algorithms

*Total marks: **50** Time: **2 hours 30 minutes***

[Answer any ***two*** questions from **Group-A** and any ***three*** questions from **Group-B**;
Separate answer script must be used for Group-A and Group-B;
Figures in the right hand margin indicate full marks.]

Group-A

1. a) Write differences between dynamic programming and greedy algorithms? **3**

b) Generate a Huffman tree and determine an optimal Huffman code for the following text: "to be or not to be it is true" **3**

c) Describe activity-selection problem. Find all possible optimal set for the following data set using activity selection problem: **4**

i	1	2	3	4	5	6	7	8	9	10	11
S_i	1	3	0	5	3	5	6	8	8	2	12
f_i	4	5	6	7	8	9	10	11	12	13	14

2. a) Show the DFS tree that results from running DFS on the following graph of **Figure 1** and classify the edges as tree edges, back edges, forward edges, or cross edges. Start at vertex **a** and examine edges in alphabetical order of destination vertex. **5**

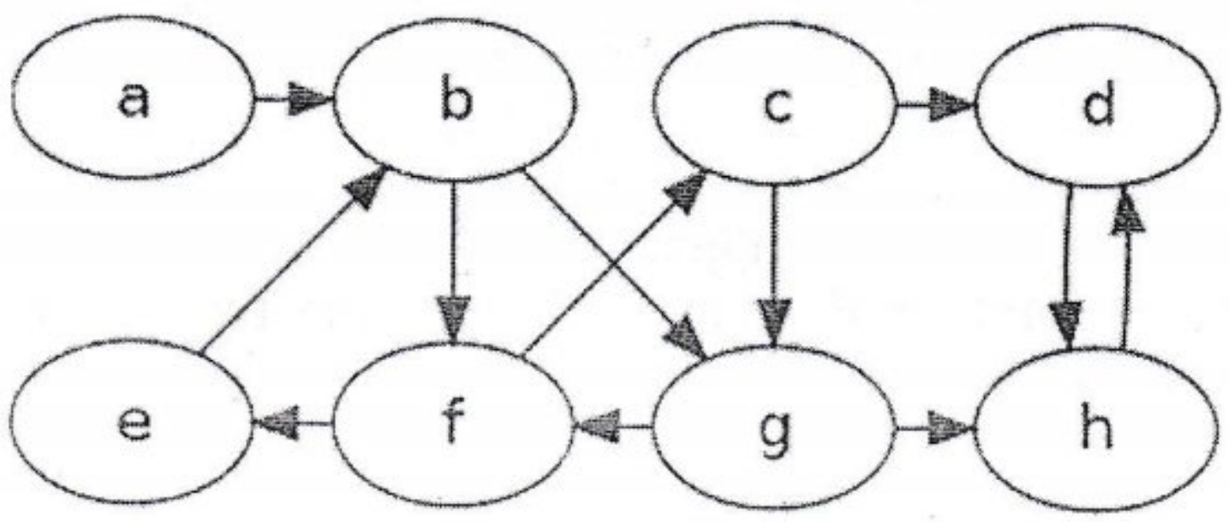


Figure 1

b) Suppose you are visiting a complete binary tree of **n** nodes using Breadth First Search (BFS) and Depth First Search (DFS) and you start from the root. After you finish visiting half of the vertices, how many leaf nodes will be visited in BFS and in DFS? An approximate answer is sufficient. **2**

c) Write down the code segment for finding following information from a given un-weighted directed graph with V vertices which is already implemented using an adjacency matrix named *graph*.

i) Make a particular vertex **v** disconnected from the rest of the graph. **1**

ii) Find th vertices where in-degree is greater than ou-degree. **2**

3.

a) Show the adja ency list and adjacency matrix of the graph in **Figure 1**. **3**

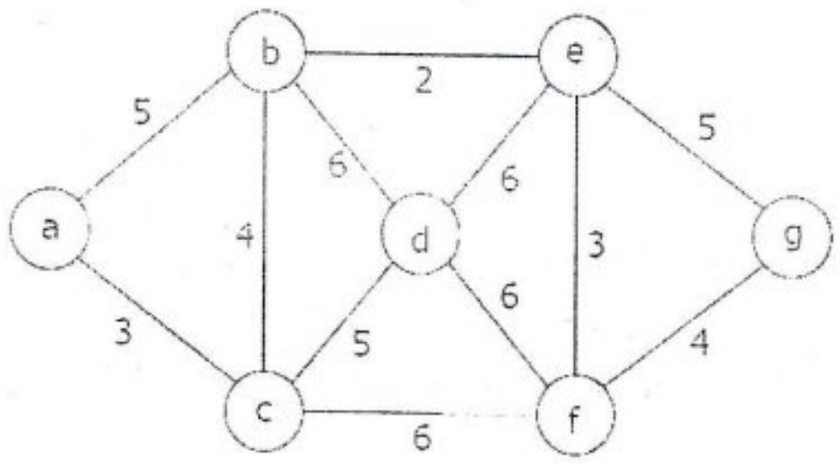


Figure 2

c) Show a topological sort of the vertices of the graph shown in Figure 3. Assume that the graph is an unweighted graph. **3**

Group-B

4.

a) Prove that subpaths of shortest paths are also shortest paths. **3**

b) Illustrate the operation of Bellman-Ford's shortest path algorithm using vertex **a** as the source on the graph in **Figure 3**. Show the steps of only first two iterations. Relax the edges in the following order: (h,e), (c,e), (d,h), (g,h), (d,g), (e,f), (f,c), (h,f), (a,e), (b,e), (a,b), (a,d) **4**

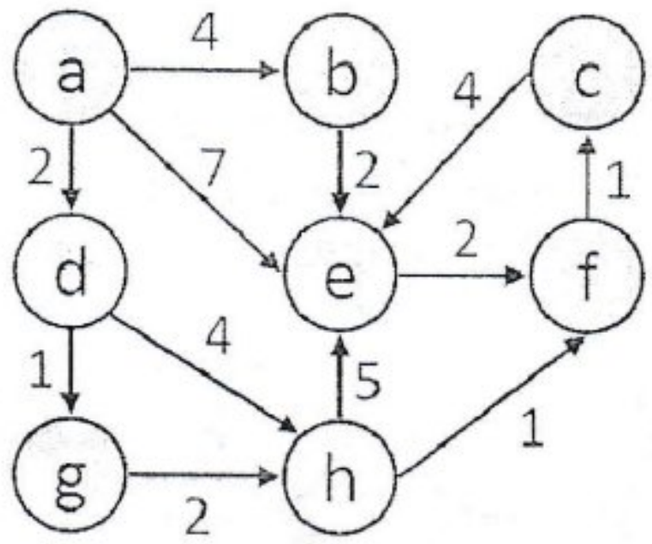


Figure 3

c) What is a *negative weight cycle*? Analyze the running time of Bellman-Ford's shortest path algorithm. **3**

5.

a) In chess, a Rook attacks any opponent piece if it is placed in the same row or same column. Let N-Rook is a problem of placing N Rooks in an N×N chessboard such that no two Rooks attack each other. Show, using a tree, how a backtracking algorithm searches the state space while solving 4-Rook problem. **3**

b) Define *Decision Problem* and *Optimization Problem*. Is the following statement correct? "Backtracking methodology can be applied to solve any decision problem given sufficient amount of time". Justify your answer. **4**

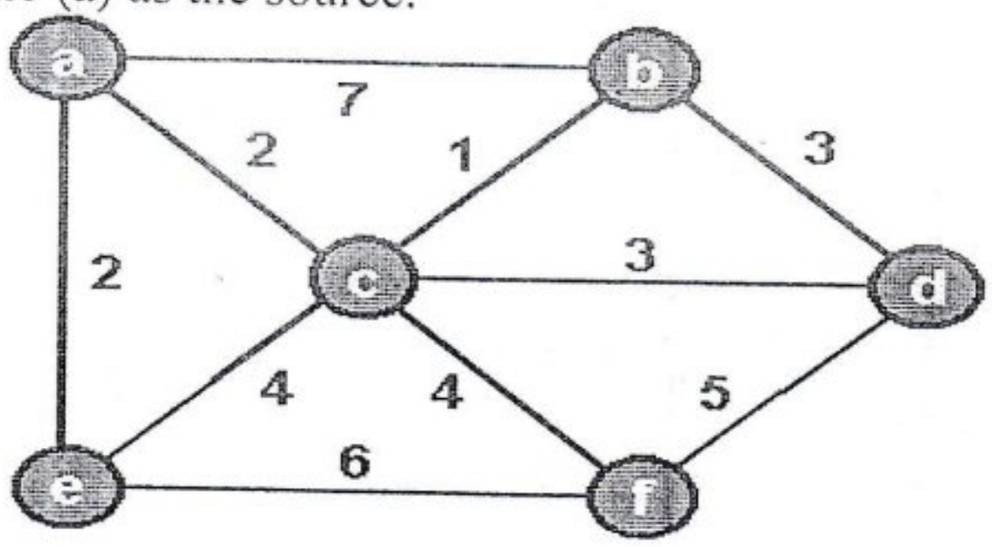
c) Define the classes P, NP and NP-Complete. **3**

6.

a) What are the four variants of shortest path algorithm? Describe briefly. **3**

b) What is *relaxation* of a vertex? Briefly discuss with necessary figure. **4**

directed graph. Assume (a) as the source.



7.

a) Describe line segment properties. How determine if two lines are collinear? 3

b) Write down the algorithm to calculate x^n mod m. 3

c) Define convex hull. Consider the following points and find convex hull using Graham's scan algorithm: 4

P1(0.7, 2.7), P2(1.8, 3.2), P3(2.6, 0.8), P4(0.9, 2.5), P5(0.6, 0.7), P6(1.5, 0.6), P7(1.5, 2.5), P8(2, 1.5), P9(1.0, 2.0), P10(0.8, 1.5).

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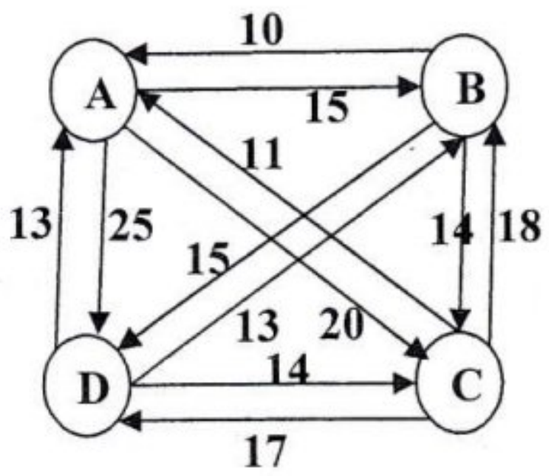
[Answer any ***two*** questions from **Group-A** and any ***three*** questions from **Group-B**;
Separate answer script must be used for Group-A and Group-B;
Figures in the right hand margin indicate full marks.]

Group-A

1.

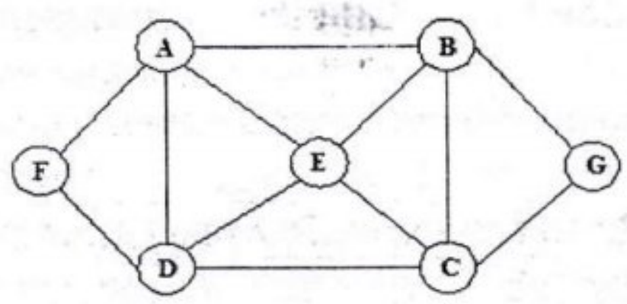
a) Define traveling salesperson problem. Apply the traveling salesperson problem on the following figure to find the optimal tour. **4**



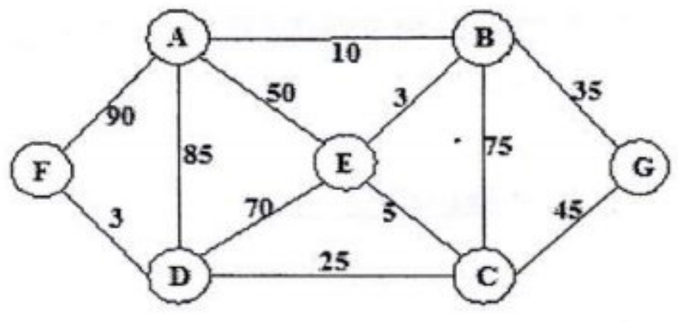
b) What is an optimal Huffman code for the following set of frequencies? **3**
a:5 b:8 c:45 d:25 e:17 f:30

c) Prove that in activity selection problem, the activity that finishes first is always part of some optimal solution. **3**

2. a) Show how Depth First Search works on following graph if E is the source **3**



b) Define spanning tree and minimum spanning tree. Construct minimum spanning tree from the graph using Kruskal Algorithm if E is the source. **4**



c) In what order do the vertices will be visited if the graph in **Figure 1** is visited using BFS and DFS. Start from vertex ***G*** and assume that the adjacency list is in lexicographic order. You only need to name the vertices. **3**

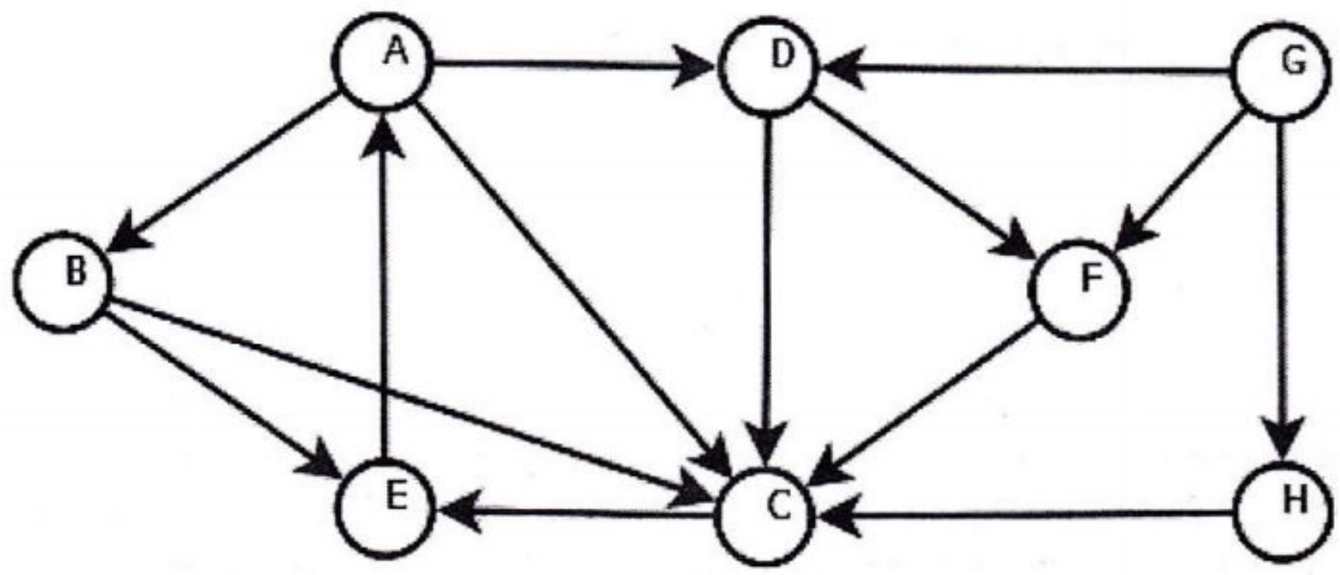


Figure 1

3.

a) Consider the graph with the following weights: w(a, b) = 1, w(a, c) = 2 , w(a, d) = 6, w(a, e) = 9, w(b,c)= 3, w(b, d) = 4, w(b, e) = 10, w(c, d) = 5, w(c, e) = 8, w(d, e) = 7. **5**

a) What minimum spanning tree would *Kruskal's* algorithm produce? Write the edges in the order that the algorithm would add them to its result.

b) What minimum spanning tree would *Prim's* algorithm produce, starting at vertex b? Write the edges in the order that the algorithm would add them to its result.

b) Describe activity-selection problem. Find all possible optimal set for the following data set using activity selection problem: **5**

i	1	2	3	4	5	6	7	8	9	10	11
S_i	1	3	0	5	3	5	6	8	8	2	12
f_i	4	5	6	7	8	9	10	11	12	13	14

Group-B

4. a)What are the four variants of shortest path algorithm? Please describe. **3**

b) Illustrate the operation of *Dijkstra's algorithm* for finding shortest path on the directed graph shown in **Figure 2**. Assume **a** as the source. Write down the **d** and **π** value of each vertex after each iteration. **5**

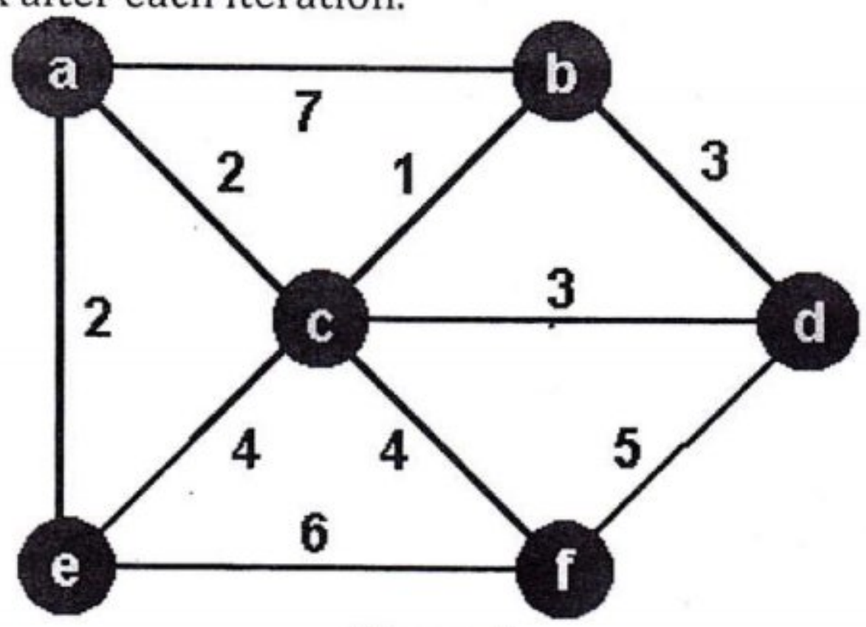


Figure 2

c) What is *relaxation* of a vertex? Briefly discuss with necessary figure. **2**

5.

a) Using suitable example show how *branch-and-bound* technique can be applied to solve *travelling salesman problem.* **4**

b) What is the significance of **NP-Complete** class in complexity theory? **3**

c) Use *recurrence tree* to solve the following recurrence $T(n) = 3T(n/3) + cn^2$. **3**

6.

a) Write down Graham's scan algorithm of convex hull construction **3**

b) Write down the algorithm to calculate x^n mod m. **4**

c) Graham's scan solves the convex hull problem by sorting the points using polar angle with respect to some point $\mathbf{P_0}$ in counter clockwise. Suppose, you are given two points $\mathbf{P_1(4,5)}$ and $\mathbf{P_2(2,3)}$. Determine which one has greater polar angle with respect to point $\mathbf{P_0(0,0)}$. **3**

7.

a) What are the applications of Branch and Bound? **4**

b) Define convex hull. Consider the following points and find convex hull using Graham's scan algorithm: **3**
P1(0.7, 2.7), P2(1.8, 3.2), P3(2.6, 0.8), P4(0.9, 2.5), P5(0.6, 0.7), P6(1.5, 0.6), P7(1.5, 2.5), P8(2, 1.5), P9(1.0, 2.0), P10(0.8, 1.5).

c) State for each of the following algorithms whether they are *greedy algorithm* or *dynamic programming (DP) algorithm* or *neither greedy nor DP.* **3**

i) Bellman-Ford's algorithm for single-source shortest path
ii) Dijkstra's algorithm for single-source shortest path
iii) Floyd-Warshall's algorithm for all-pairs shortest path
iv) Graham's scan algorithm for finding convex hull
v) Kruskal's algorithm for finding minimum spanning tree
vi) Huffman's algorithm for finding optimal prefix code

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Separate answer script must be used for Group-A and Group-B;
Figures in the right hand margin indicate full marks.]

Group-A

1.a) What is a greedy choice? Show that you can make a greedy choice when solving fractional knapsack problem but cannot do that when solving 0/1 knapsack problem. **3**

b) Suppose you have following characters with the given frequencies. **4**

a:3 b:5 c:8 d:13 e:21

Following prefix code has been assigned for the characters.

e = 0, d = 11, c = 111, b = 1111, a = 11111

Find whether this is optimal.

[Hint: Construct Huffman tree and compare the cost.]

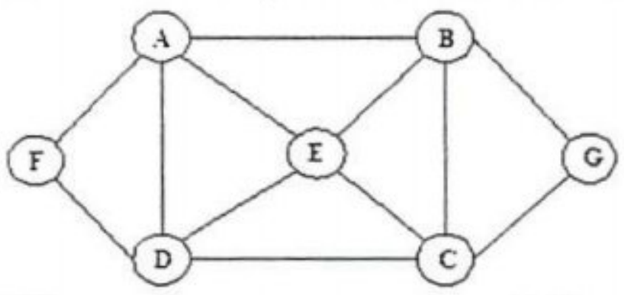
c) With the help of counterexample, show that the following are not a part of an optimal solution of activity selection problem. **3**

i) Activity taking shortest amount of time

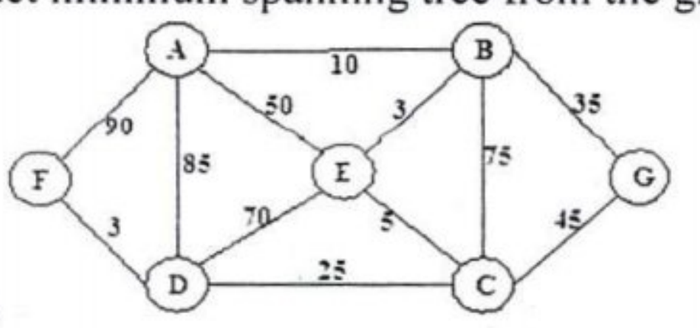
ii) Activity that starts first

2.a) Give advantages and disadvantages of BFS with respect to DFS. **3**

b) Show how Depth First Search works on following graph if E is the source. **3**



c) Why we have to span a tree? Construct minimum spanning tree from the graph using Kruskal Algorithm if E is the source. **4**



3.a) Find a *minimum spanning tree* for the graph in **Figure 2** using *Prim's algorithm* and show the steps in figure. **5**

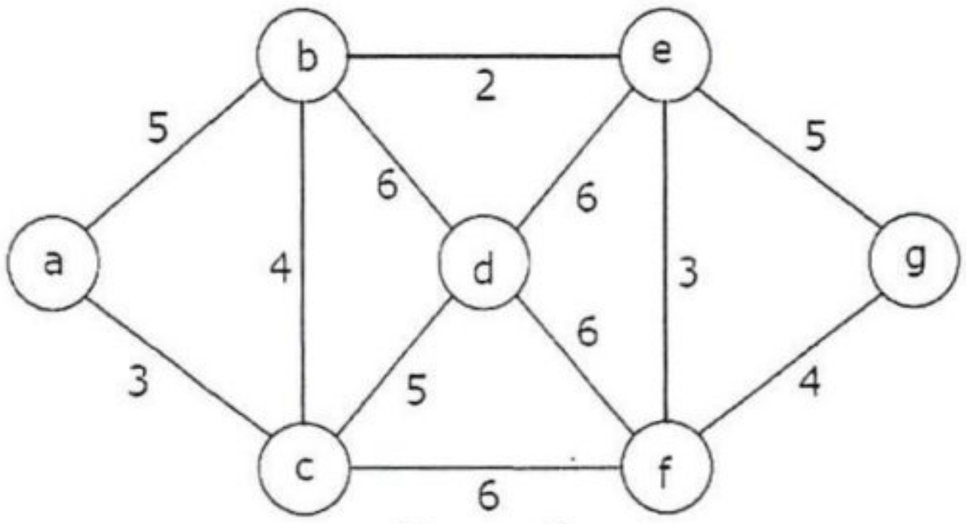


Figure 2

b) Kruskal's algorithm selects the shaded edges for finding MST of the graph in **Figure 3**. Which edge will be selected in the next iteration? Justify your choice. **3**

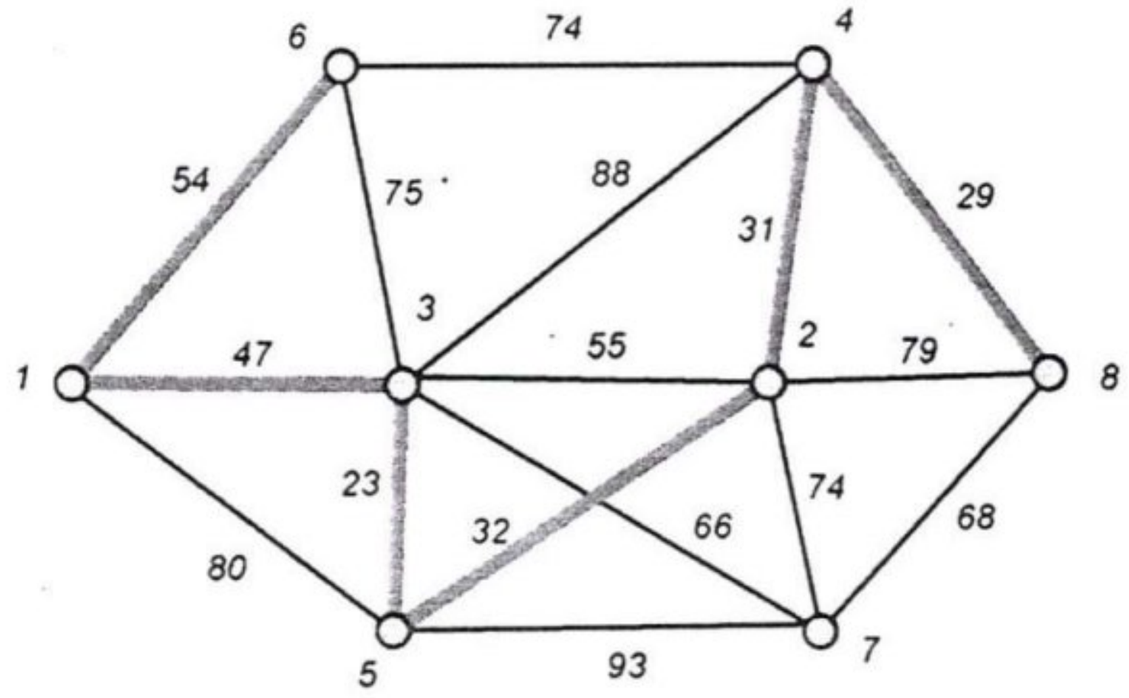


Figure 3

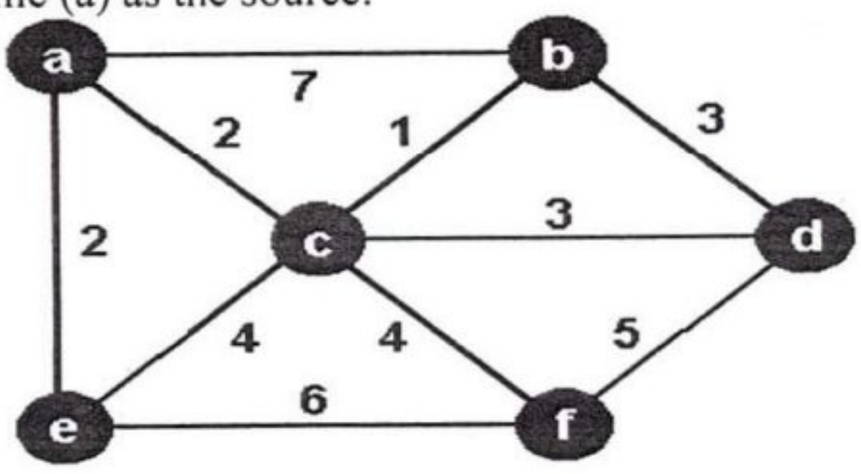
c) Using a suitable example show that the Minimum Spanning Tree (MST) of a graph is not always unique. Give a condition for which MST of a graph will be unique. **2**

Group-B

4.a) What are the four variants of shortest path algorithm? Please describe. **3**

b) Briefly discuss why relaxation of a vertex is necessary and useful. **3**

c) Illustrate the operation of *Dijkstra's algorithm* for finding shortest path on the following directed graph. Assume (a) as the source. **4**



5.

a) What is the basic principle of a Branch-and-Bound algorithm? Explain how you will apply it in solving *travelling salesman problem*. 4

b) In chess, a Rook attacks any opponent piece if it is placed in the same row or same column. Let N-Rook is a problem of placing N Rooks in an N×N chessboard such that no two Rooks attack each other. Show, using a tree, how a backtracking algorithm searches the state space while solving 4-Rook problem. 3

c) Define the classes **P**, **NP** and **NP-complete**. 3

6.a) Analyze the convex hull problem. 3

b) Define *cross product* of two vectors as used in computational geometry. Describe how the cross product of two vectors can be used to determine whether two line segments intersect or not. 3

c) Consider the following points and find convex hull using Graham's scan algorithm: P1(0.7, 2.7), P2(1.8, 3.2), P3(2.6, 0.8), P4(0.9, 2.5), P5(0.6, 0.7), P6(1.5, 0.6), P7(1.5, 2.5), P8(2, 1.5), P9(1.0, 2.0), P10(0.8, 1.5). 4

7.a) Find $D^{(0)}$ and $\Pi^{(0)}$ from the graph in **Figure 2** for *Floyd-Warshall's algorithm*. Now find $D^{(1)}$ and $\Pi^{(1)}$. Assume that the vertices are numbered lexicographically. 4

b) Let $P_1(x_1,y_1)$, $P_2(x_2,y_2)$ and $P_3(x_3,y_3)$ are three points. Show that if going through P_1, P_2, P_3 has a left turn at P_2 then going through P_3, P_2, P_1 has a right turn at P_2. 3

c) Prove that $d_{ij}^{k} = \min\left(d_{ij}^{k-1}, d_{ik}^{k-1} + d_{kj}^{k-1}\right)$ using the concept of intermediate vertex. Assume that d_{ij}^{k} is the weight of the minimum weight path from vertex ***i*** to vertex **j** where the intermediate vertices are drawn from the set {1, 2, 3, ... k}. 3

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Total marks: 50 *Time: 2 hours 30 minutes*

[The figures in the right hand margin indicate full marks. Course Outcomes and Bloom's Taxonomy Levels are mentioned in additional columns]

Group A

				CO	DL
1.					
a)	Greedy strategy does not give the optimal solution for 0/1 knapsack. Do you agree with this statement? Justify your answer with example.	5	CO2	An
b)	You have been asked to encode a paragraph with Huffman coding scheme. This paragraph contains the following symbols along with their associate frequency in the paragraph.	5	CO5	Ap p

A	B	C	D	E	F	G	H	I	J
3	3	26	5	3	8	13	2	16	9

Draw the corresponding Huffman tree and utilizing that tree tell the binary encoding for each letter.

OR

Suppose we have a knapsack that has a weight limit w. There are items i1, i2, ..., in each having weight w1, w2, ..., wn and some benefit associated with it v1, v2 ,..., vn. We need to maximize the benefit such that the total weight inside the knapsack is at most w. Demonstrate an algorithm to solve this problem

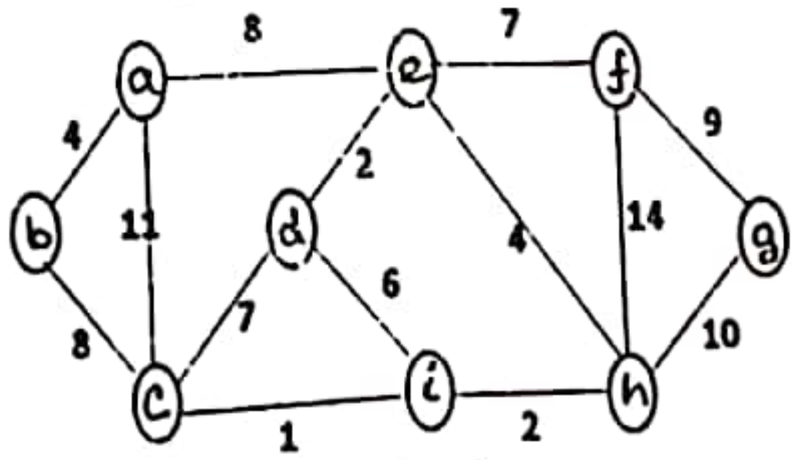
2.				
a)	Draw the following undirected graph G = {a, b, c, d, e, f, g, h, i} E = {(a,b), (a,d), (b,c), (c,d), (c,e), (d,e), (d,g), (f,e), (g,f), (g,i), (h,d), (h,g), (i,f)} Traverse the graph using Breadth First Search starting from vertex **h**. Visit the nodes in lexicographic order (a, b, c ...). Show only the final breadth first tree along with **d** and **π** values. You don't need to show the intermediate steps.	3	CO1	A

OR

Traverse the graph using Depth First Search and show the discover time **d** and finish time **f**. You don't need to show the intermediate steps.

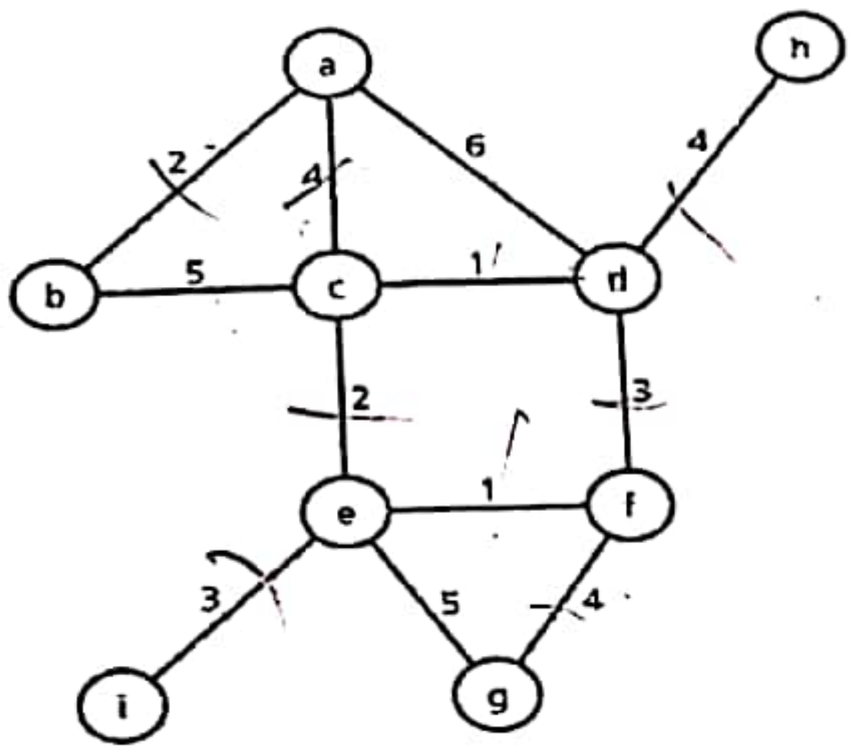
b)	Write an algorithm for finding the in-degree of each vertex a graph **G**. G is represented with an adjacency list. What will be the running time of your algorithm?	3	CO2	

b) Write the definition of minimum spanning tree. Consider the following graph. What minimum spanning tree would Prim's algorithm produce? Write the edges in the order that the algorithm would add them to its result. 5 CO1 A



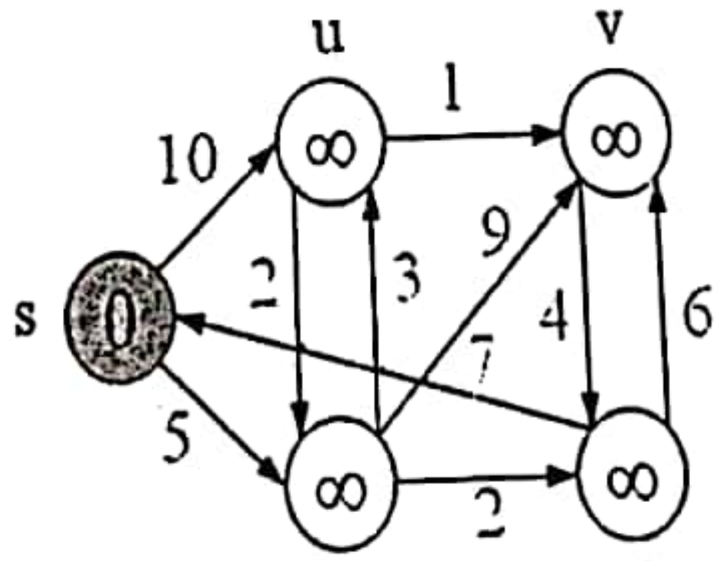
OR

Write the definition of minimum spanning tree. Consider the following graph. What minimum spanning tree would Kruskal's algorithm produce? Write the edges in the order that the algorithm would add them to its result.



Group B

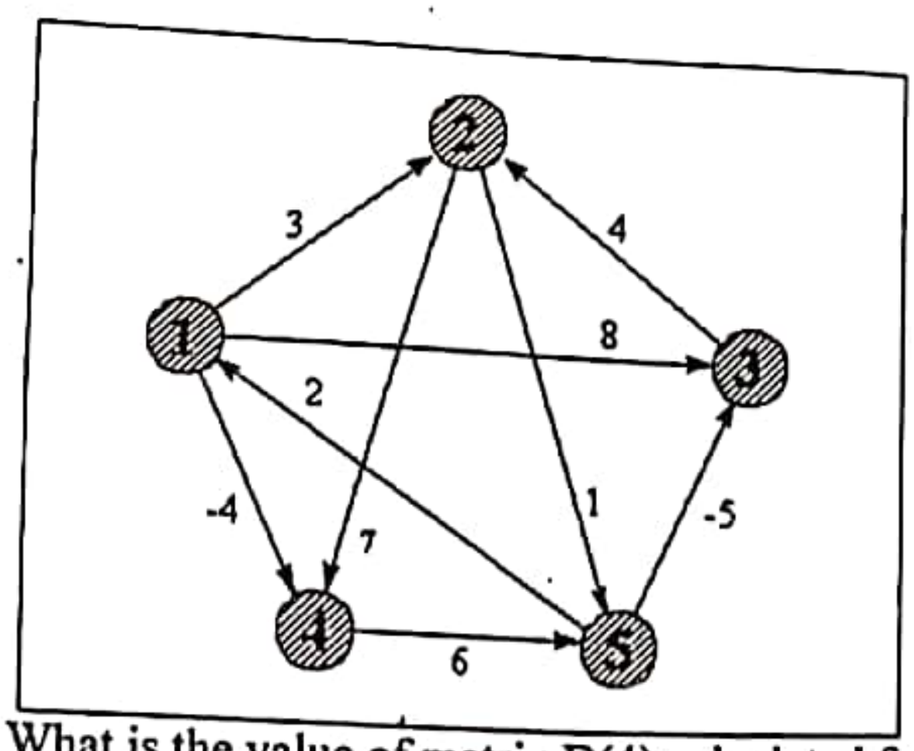
3 a) Run the Dijkstra's algorithm to find single source shortest path on the weighted directed graph in following figure. 5 CO2 L



b) Describe the Bellman-Ford algorithm with necessary figure. 5 CO1

OR

Consider the following graph for finding all pair shortest path using Floyd-Warshall algorithm. **CO5 E**



	0	3	8	7	-4
	inf	0	Inf	1	7
D(3) =	inf	4	0	5	11
	2	-1	-5	0	-2
	inf	inf	Inf	6	0

What is the value of matrix D(4) calculated from matrix D(3) given above.

4.

a) Let $P_1(x_1,y_1)$, $P_2(x_2,y_2)$ and $P_3(x_3,y_3)$ are three points. Show using the concept of that if going through P_1, P_2, P_3 has a left turn at P_2 then going through P_3, P_2, P_1 has a right turn at P_2. You have to show it using the concept of cross product. **3 CO1 A**

OR

Suppose, you are given two points $P_1(3,7)$ and $P_2(9,2)$. Determine which one has greater polar angle with respect to

i) Origin (0, 0)
ii) (20, 0)

b) How can you determine whether two line segments are collinear or not? Describe the basic idea using figure. **3 CO1 C**

OR

Given three points on a 2D plane, how can you determine whether they form a triangle or not using the concept of cross product?

c) Prove that the subpaths of shortest paths are also shortest paths. **4 CO3 N**

5.

a) Consider the 4-queen problem. Your task is to place the 4 queens in 4X4 chessboard so that no two queens attack each other. **3 CO2 A**

i. What is a dead node in N-queen problem?
ii. Design a state space tree which represents all possible arrangements for 4 non-attacking queens.

b) Define the following classes: P, NP, NP-complete. **3 CO4 U**

c) What is the basic principle of a Branch-and-Bound algorithm? Explain how you will apply it in solving *travelling salesman problem*. **4 CO5 A**

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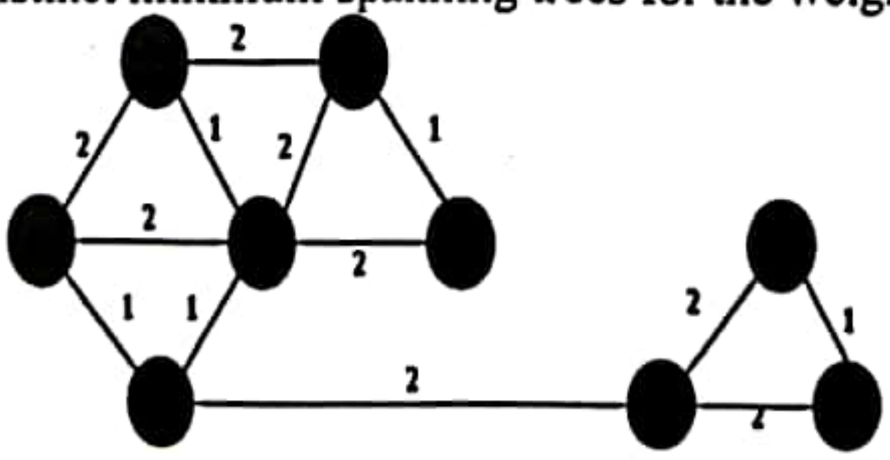
Group A

1.a	Explain with example what a greedy choice is. **OR** Prove that activity selection problem has greedy choice property.	CO5	E	3
b.	Suppose you have to pay **X** taka in a shop using minimum number of notes. You have 20, 10, 5, 2, 1 taka notes with you. Write a greedy algorithm to do this.	CO5	C	3
c.	Determine an optimal Huffman code for the following set of frequencies: **a:M, b:3, c:18, d:12, e:N, f:6, g:21, h:42** *(Note: M is the sum of last two digits of your ID and N is the last two digits of you ID. i.e. if your ID is C151216, then M=1+6=7, and N=16).*	CO1	A	4
2.a	Analyze the running time of Prim's algorithm if the priority queue is represented by a binary heap. **OR** Analyze the running time of Dijkstra's single-source shortest algorithm if the priority queue is represented by a binary heap.	CO1	N	3
b)	Write down the code segment for finding following information from a given un-weighted directed graph with V vertices which is already implemented using an adjacency matrix named *graph*. i) Find the in-degree of each vertex. ii) Find whether there is any loop in the graph.	CO2	A	3
c)	Consider a complete undirected graph with vertex set {0, 1, 2, 3, 4}. Entry Wij in the matrix W below is the weight of the edge {i, j}. What is the minimum possible weight of a spanning tree T in this graph such that vertex 0 is a leaf node in the tree T?	CO1	A	4

0	1	8	1	4
1	0	12	4	9
8	12	0	7	3
1	4	7	0	2
4	9	3	2	0

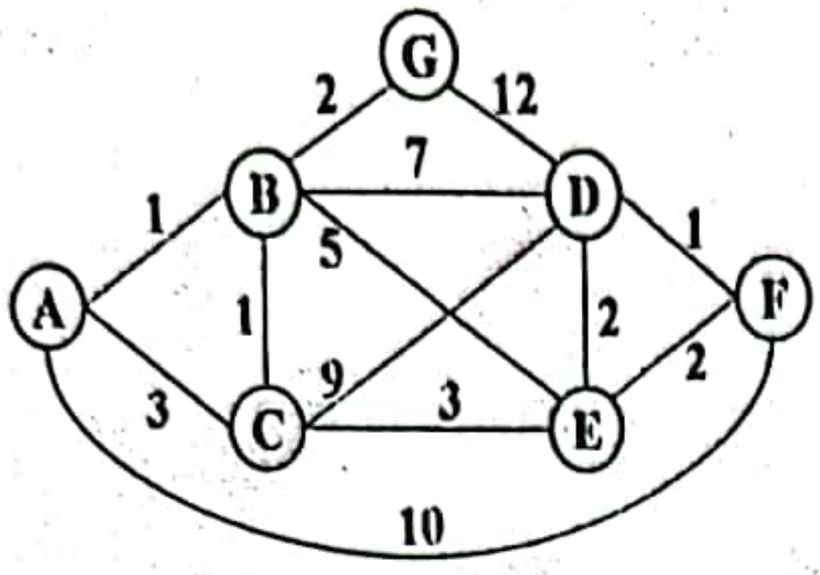
OR (for 2c)

Find the number of distinct minimum spanning trees for the weighted graph below.



Group B

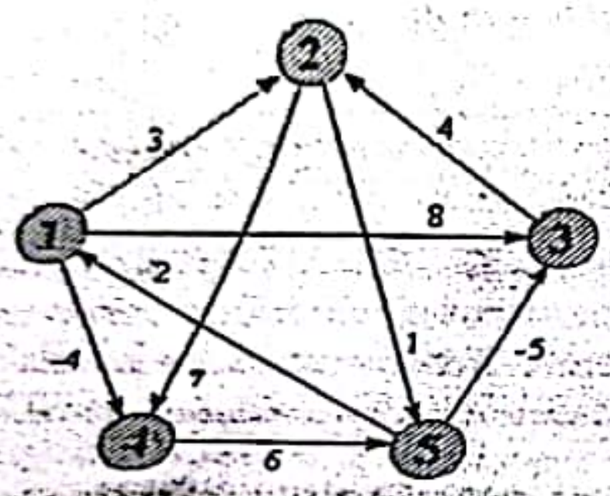
3.a	Run the Dijkstra's algorithm to find single source shortest path on the weighted directed graph of the following figure using vertex *G* as the source.	CO1	A	



OR

Run the Bellman-Ford's algorithm to find single source shortest path on the weighted directed graph of the above figure using vertex *G* as the source.

b.	Consider the following graph for finding all pair shortest path using Floyd-Warshall algorithm.	CO1	A	5



D(3) =

0	3	8	7	-4
inf	0	inf	1	7
inf	4	0	5	11
2	-1	-5	0	-2
inf	inf	inf	6	0

What is the value of matrix D(4) calculated from matrix D(3) given above.

OR

Find the transitive closure of the directed graph given above using Warshall's algorithm. Show the matrix $T^{(k)}$ that results for each iteration of the outermost loop.

4.a	Suppose that an ant is traveling from point A(5,3) to point B(17,9) in straight line, and from there it started to travel towards point C(2,6). Did the ant turn to left or right at point B? From point C it travelled towards point D(5,12). What turn did the ant make at point C, left or right? Show using the technique of cross-product.	CO1	C	5
b.	i) Plot the following points on a Cartesian coordinate plane. An approximate drawing is sufficient. [(4,3),(8,4),(10,5),(6,7),(2,8),(5,8),(2,2),(6,5),(1,8),(3,3),(12,3),(0,2)]	CO1	A	5
	ii) Sort the above points according to polar angle with respect to the point which is the lowermost and in case of a tie the leftmost.			
	iii) Find the convex hull of these points using Graham's Scan algorithm.			
5.a	Explain why NP-complete class is important in complexity theory.	CO4	U	2
b.	What is the basic principle of reducing the solution / state / search space in branch and bound technique? If required use a suitable example.	CO5	A	4
c.	In chess, a Rook attacks any opponent piece if it is placed in the same row or same column. Let N-Rook is a problem of placing N Rooks in an N×N chessboard such that no two Rooks attack each other. Show, using a tree, how a backtracking algorithm searches the state space while solving 4-Rook problem.	CO2	A	4