Student Answer Sheet Analysis

Automated Processing

October 28, 2025

Questions and Answers

For each question below, show the question text followed by the student's answer.

Question 1(a): Consider the following incidence matrix of a simple undirected graph. Convert this into an adjacency matrix representation.

Student Answer: Given Incidence Matrix

$$\begin{bmatrix} 1 & 0 & 0 \\ 1 & 1 & 1 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Consider row as nodes - 4 nodes Consider column as edges - 3 edges Find adjacency matrix by following label mapping Edge 1 connects node A & B Edge 2 connects node B & C Edge 3 connects node B & D

$$\begin{bmatrix} 0 & 1 & 0 & 0 \\ 1 & 0 & 1 & 1 \\ 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 \end{bmatrix}$$

Question 1(b): Which network model assumes that edges are formed between pairs of nodes with a uniform probability, independent of other edges?

Student Answer: Ans. B. Erdős–Rényi (Random Network) Model It creates edges between pairs of nodes is formed independently with equal probability.

Question 1(c): In game theory, a situation where no player can improve their outcome by unilaterally changing their strategy, given the strategies of other players, is known as:

Student Answer: Ans C. Nash Equilibrium It states where no player can benefit by unilaterally changing their strategy, assuming all other players are holding their strategies constant.

Question 1(d): The tendency for individuals in a social network to associate and bond with similar others is defined as:

Student Answer: B. Assortative Mixing The tendency of nodes in a network to connect with other nodes that have similar characteristics.

Question 1(e): Why might betweenness centrality be a more relevant measure than degree centrality for identifying critical nodes in a network transmitting information that must follow specific paths?

Student Answer: P. Because it quantifies how often a node lies on the shortest paths between other nodes.

Question 1(f): A key

Student Answer: The presence of many nodes with very high degrees (hubs) that maintain connectivity.

Question 1(g): No Question on Paper. Student answered nonetheless.

Student Answer: The number of intra-community edges is significantly higher than expected in random network with the same degree sequence.

Question 1(h): No Question on Paper. Student answered nonetheless.

Student Answer: X: A, B, C, D Y: C, M, E $A \cap B = 5$ $X \cup Y = 5$ $A \cup B = 5$ $X \cap Y = 2$ Jaccard Coefficient = $\frac{2}{5}$ β=.75

Question (2): No Question on Paper. Student answered nonetheless.

Student Answer: A. GCN uses node probabilities independently: GNN uses a weighted sum of active neighbours compared to a node threshold.

Question (3): No Question on Paper. Student answered nonetheless.

Student Answer: B. Because assigning features from dissimilar neighbors can blur the nodes own representative features, making classification harder.

Question (4): No Question on Paper. Student answered nonetheless.

Student Answer: Vaccination strategy using network analysis. a. Betweenness centrality - It helps to identify nodes that act as bridges between different communities. These nodes often lie on the shortest paths between many pairs of nodes and control the flow of the infection between different parts of the network.

b. Degree centrality - It helps to identify high degree nodes that have many connections and higher potential to spread the virus.

Question (5)(a): No Question on Paper. Student answered nonetheless.

Student Answer: The core idea behind Girvan-Newman algorithm is to identify communities in a network by iteratively removing edges with high betweenness centrality until the network breaks down into smaller, well defined groups.

Question (5)(b): No Question on Paper. Student answered nonetheless.

Student Answer: Betweenness centrality measures how often a node lies on the shortest path between other nodes in a network. -It helps to calculate betweenness centrality for all edges in the network. - Removing the edge with highest betweenness centrality

Question (5)(c): No Question on Paper. Student answered nonetheless.

Student Answer: Major computational limitation of Girvan-Newman Algorithm is its high computational complexity. -For a network nodes m edges with calculation with O(n^2m). $-Thiscalculationmustberepeatedafterremovingeachedge.-Overall,thismakesthealgorithmimpracticalfo$

Question (5)(d): No Question on Paper. Student answered nonetheless.

Student Answer: Louvain method provides a more scalable alternative for optimizing modularity through: -Local optimization - It starts by assigning each node to its own community. Then iteratively moves individual nodes to communities that result in the largest increase in modularity. -Hierarchical Aggregation- It creates new network where nodes are the communities found in the previous step. Iteration on reduced network allows it to detect Multilevel community structure.

Question (5)(e): No Question on Paper. Student answered nonetheless.

Student Answer: Page Rank Algorithm -Intuition behind PageRank is based on the idea that the popularity of a webpage is determined not only by the number of incoming links but also by the kind of incoming links. Citations from highly ranked pages contribute more than lower ranked webpages.

Question (5)(b): No Question on Paper. Student answered nonetheless.

Student Answer: Role of Damping factor (d). Damping factor (d) suppresses the probability that the random surfer will follow an outgoing link rather than randomly teleporting to another page.

Question (5)(c): No Question on Paper. Student answered nonetheless.

Student Answer: Problems with dangling nodes. Dangling nodes create a sink in pagerank calculation. It causes all Pagerank values to approach zero.

Question (6): No Question on Paper. Student answered nonetheless.

Student Answer: Given Payoff Matrix

	Strategy-A	Strategy-B
Strategy-U	(3,2)	(0,1)
Strategy-L	(2,0)	(1,3)

Question (6)(a): No Question on Paper. Student answered nonetheless.

Student Answer: Pure Strategy (U,A) - Player 1 gets 3, Player 2 gets 2 (U,B) - Player 1 gets 0, Player 2 gets 1 (L,A) - Player 1 gets 2, Player 2 gets 0 (L,B) - Player 1 gets 1, Player 2 gets 3

Question (6)(b): No Question on Paper. Student answered nonetheless.

Student Answer: For Expected Payoffs for A $E[A] = P*2 + (1-P)*0 = 2P$ Expected Payoffs for B $E[B] = P*1 + (1-P)*3 = P+3-3P = 3-2P$

Question (6)(c): No Question on Paper. Student answered nonetheless.

Student Answer: Expected outcome of P=0.7 E[A] = 2P = 2*0.7 = 1.4 E[B] = 3-2P = 3-2*0.7 = 1.6

Question (7): No Question on Paper. Student answered nonetheless.

Student Answer: Neighbors of B n(B) = S, A, D Given feature vectors $h_A^{(0)} = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$, $h_C^{(0)} = \begin{bmatrix} 3 \\ 4 \end{bmatrix}$, $h_D^{(0)} = \begin{bmatrix} 2 \\ 2 \end{bmatrix}$

Find average of initial feature vectors. $h_{n(B)}^{(0)} = \frac{1}{3}(h_A + h_C + h_D) = \frac{1}{3}(\begin{bmatrix} 1 \\ 1 \end{bmatrix} + \begin{bmatrix} 3 \\ 4 \end{bmatrix} + \begin{bmatrix} 2 \\ 2 \end{bmatrix})$ $= \frac{1}{3}(\begin{bmatrix} 6 \\ 7 \end{bmatrix}) = \begin{bmatrix} 2 \\ 2.33 \end{bmatrix}$

Given weight Matrix $W^{(0)} = \begin{bmatrix} 0.5 & 0.2 \\ 0.1 & 0.2 \end{bmatrix}$

$W * h_{n(B)}^{(0)} = \begin{bmatrix} 0.5 & 0.2 \\ 0.1 & 0.2 \end{bmatrix} \begin{bmatrix} 2 \\ 2.33 \end{bmatrix} = \begin{bmatrix} 0.5 * 2 + 0.2 * 2.33 \\ 0.1 * 2 + 0.2 * 2.33 \end{bmatrix} = \begin{bmatrix} 1 + 0.47 \\ 0.2 + 0.47 \end{bmatrix} = \begin{bmatrix} 1.47 \\ 0.67 \end{bmatrix}$