Student Answer Sheet Analysis

Automated Processing System

July 5, 2025

Instructions

This document contains the extracted questions and corresponding student answers from the submitted answer sheet.

For each question below: - The question text appears first in regular formatting - The student's answer follows in a clearly marked answer section - Mathematical expressions are properly formatted using LaTeX

1 Questions and Answers

1.1 Question 1a

Question: Given the incidence matrix

Student Answer:

Given the incidence matrix

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

Consider rows as nodes - 4 nodes Consider columns as edges - 3 edges

->Find adjacency matrix by following 1 to 1 mapping Edge 1 connects node A & B. Edge 2 connects node B & C Edge 3 connects node B & D

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

1.2 Question 1b

Question:

Student Answer:

Ans: B. Erdős–Rényi (random network model) - It creates edges between pairs of nodes is formed independently with equal probability.

1.3 Question 1c

Question:

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.

1.4 Question 1d

Question:

Student Answer:

B. Assortative mixing - The tendency of nodes in a network to connect with other nodes that have similar characteristics.

1.5 Question 1e

Question:

Student Answer:

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

1.6 Question 1f

Question:

Student Answer:

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

1.7 Question 1g

Question:

Student Answer:

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

1.8 Question 1h

Question:

Student Answer:

X: A, B, C, D Y: C, M, E AUB = 5 XUY = 5 AB = *No answer provided* XY = 2

Jaccard Coefficient = $\frac{2}{5}$

B = 0.36

1.9 Question 1i

Question:

Student Answer:

A. GNN uses edge probabilities independently; GCN uses a weighted sum of active neighbours compared to a node threshold.

1.10 Question 1j

Question:

Student Answer:

B. Because edges originating from dissimilar neighbours can blur the nodes own representative features, making classification harder.

1.11 Question 2

Question:

Student Answer:

Validation 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.

1.12 Question 4a

Question:

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.

1.13 Question 4b

Question:

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

1.14 Question 4c

Question:

Student Answer:

Major computational limitation of Girvan-Newman Algorithm is its high computational complexity. - For a network n nodes & m edges will calculation with O(mn) time. - This calculation must be repeated after removing each edge. - Overall this makes the algorithm impractical for large networks with thousands/millions of nodes & edges.

1.15 Question 4d

Question:

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 a new network where nodes are the communities found in the previous step. - Iteration on Reduced network - It repeats the process on this smaller network allowing it to detect multilevel community structure.

1.16 Question 5a

Question:

Student Answer:

PageRank 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. Situations from highly ranked pages contribute more than lower ranked webpages.

1.17 Question 5b

Question:

Student Answer:

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

1.18 Question 5c

Question:

Student Answer:

Problems with dangling nodes. - Dangling nodes create a leak in pageRank calculation - it causes all pageRank values to approach zero.

1.19 Question 6

Question:

Student Answer:

Given payoff matrix:

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

1.20 Question 6a

Question:

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

1.21 Question 6b

Question:

Student Answer:

For Expected payoffs for A E[A] = p x 2 + (1-p) x 0 = 2p Expected payoffs for B E[B] = p x 1 + (1-p) x 3 = p + 3 - 3p = 3-2p

1.22 Question 6c

Question:

Student Answer:

Expected outcome of p = 0.7 E[A] = 2p = 2 x 0.7 = 1.4 E[B] = 3 - 2p = 3 - 2 x 0.7 = 1.6

1.23 Question 7

Question:

Student Answer:

Neighbours of B or N(B) = A, C, 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.

$h_{N(B)}^{(0)} = \frac{1}{3}(h_A + h_C + h_D) = \frac{1}{3}\begin{bmatrix}1\\1\end{bmatrix} + \begin{bmatrix}3\\4\end{bmatrix} + \begin{bmatrix}2\\2\end{bmatrix} = \frac{1}{3}\begin{bmatrix}6\\7\end{bmatrix} = \begin{bmatrix}2\\7/3\end{bmatrix}$

Given weight Matrix

$w^{(0)} = \begin{bmatrix}0.5 & 0\\0.1 & 0.2\end{bmatrix}$ $Wxh_{N(B)}^{(0)} = \begin{bmatrix}0.5 & 0\\0.1 & 0.2\end{bmatrix}\begin{bmatrix}2\\7/3\end{bmatrix}$

$= \begin{bmatrix}0.5x2 + 0x(7/3)\\0.1x2 + 0.2x(7/3)\end{bmatrix} = \begin{bmatrix}1\\0.66\end{bmatrix}$