DSGT — Discrete Structures & Graph Theory

Scanned question papers, topic-wise · Dec 2025 (QP 99814) + May 2026 (QP 14827)

Every question is the original scanned print from the university paper — nothing re-typed.

SOLVING QUESTIONS

Topic-wise · Dec 2025 + May 2026 · 26 questions

1. Pigeonhole Principle

Dec 2025 · Q1c · 5 marks

Q.1 c) A programming contest has 240 participants and 12 judging terminals.

i. Using Pigeonhole Principle, find the minimum number of contestants who must end up using the same terminal.

ii. Explain how this insight helps in contest scheduling, load balancing, and avoiding terminal bottlenecks.

May 2026 · Q1c · 5 marks

c) A quality control department stores 10 pairs of socks of different colors in a drawer for packaging verification.
Using the **Pigeonhole Principle**, analyze the minimum number of socks that must be Selected randomly to guarantee that at least one matching pair of the same color is obtained. Justify your answer with suitable reasoning. (05M)

2. Propositional Logic — Truth Tables & Equivalence Proofs

Dec 2025 · Q1b · 5 marks

Q.1 b A college bus attendance system gives "Boarded = True" when: **(05M)**

P: The student taps RFID card
Q: Bus mentor manually verifies student
R: The system logs boarding record

The transport officer rewrites: $(P \vee Q) \rightarrow R \equiv (P \rightarrow R) \wedge (Q \rightarrow R)$

i. Prove the above using logical equivalence laws step-by-step.

ii. Explain how this version ensures no boarding method is ignored, improves data consistency, and reduces false "absent" cases.

Dec 2025 · Q1d · 5 marks

Q.1 d) A Cybersecurity lab access is granted if: **(05M)**

P: Student has lab clearance
Q: Student has signed NDA
R: Student completed safety briefing

Access expression: $A = (P \wedge Q) \vee (P \wedge R)$

i. Construct truth table for A

ii. Identify combinations where access is wrongly granted.

iii. Explain consequences for security, safety compliance, and audit records.

May 2026 · Q1b · 5 marks

b) A software security system uses logical rules to decide whether access should be granted, denied, or forwarded for further verification.
Consider the following logical expressions:

$$((p \rightarrow q) \rightarrow r)$$

and

$$(p \wedge \neg q) \vee r$$

Using a series of logical equivalences, prove that the two expressions are logically equivalent. Also interpret how logical equivalence helps simplify decision rules in software systems. (05M)

3. Functions — Mapping Types & Composition

Dec 2025 · Q1e · 5 marks

Q.1 e) Students are assigned to specialization tracks based on the following rule: **(05M)**

- Score in Coding ≥ 80 → Software Track
- Score in Networks ≥ 75 → Network Security
- Score in Math ≥ 85 → Data Science

(Priority: Data Science > Software > Network Security)

Paper / Subject Code: N2113112 / Discrete Structures andGraph Theory

SE/SEM-III/ NEP/ Dec-25/ Computer/ CSE(OT)/ AIDS (2/4)
Q.P. Code: 998140
19/12/25

Given sample data (Coding, Networks, Math):

S1: (85, 60, 70)
S2: (65, 80, 90)
S3: (82, 78, 88)
S4: (78, 76, 60)

i. Map each student to a track.
ii. Check if the mapping is function / one-one / onto / many-one.
iii. Explain how these properties impact batch size planning, mentor allocation, and fairness.

Dec 2025 · Q2b · 7 marks

Q.2 b) A university assigns raw marks to final grades using: **(07M)**

Moderation function - $M(x) = x + 5$
Weight conversion - $W(x) = 0.4x$
Compute the compositions:

i. $W \circ M$ ii. $M \circ W$ iii. $M \circ M$ iv. $W \circ W$

Interpret each composition in the grading context, and discuss which are academically meaningful and which may distort scores.

May 2026 · Q2b · 7 marks

Q.1 - KTEU24 (1)

b) A retail store offers seasonal discounts on clothing items. A customer wants to purchase a shirt priced at Rs.1000. The store first provides a **15% discount**, after which an **8% sales tax** is applied to the discounted price.
Based on this shopping scenario:

1. Develop suitable mathematical functions representing the discount process and the tax calculation process.
2. Construct the **composite function** representing the final cost of the shirt.
3. Determine the final amount to be paid by the customer.
4. Analyze how composite functions help automate billing systems in retail applications. (07M)

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4. Inclusion–Exclusion Principle (Sets)

Dec 2025 · Q2a · 8 marks

Q.2 a) A campus event app records students who use three app sections: (08M)

- E: Event Announcements
- C: Clubs & Communities
- R: Reels / Short videos

Survey data:

Category	Count
E	140
C	110
R	120
E ∩ C	65
E ∩ R	70
C ∩ R	55
Total Students	200

i. Using inclusion–exclusion, compute how many students use all three sections.
ii. Find students who use only one section.
iii. iii. Explain how this analysis helps app developers and event committees design targeted notifications and UI improvements.

May 2026 · Q2a · 8 marks

Q. 2 a) A pharmaceutical company conducts a drug trial on **1000 people** to analyze the side effects of a newly developed medicine. The following observations are recorded:

- 122 people develop symptom A
- 88 people develop symptom B
- 112 people develop symptom C
- 27 people develop both symptoms $A$and B
- 29 people develop both symptoms $A$and C
- 32 people develop both symptoms $B$and C
- 10 people develop all three symptoms A, B, and C

Using the **Principle of Inclusion and Exclusion**:

1. Analyze how many people develop **at least one symptom**.
2. Determine the number of people who show **exactly one symptom**.
3. Construct a **Venn diagram** and fill all regions appropriately.

5. Transitive Closure & Warshall's Algorithm

Dec 2025 · Q3a · 8 marks

Paper / Subject Code: N2113112 / Discrete Structures andGraph Theory

S·E/Sem-III/ NEP/ Dec-25 /Computer/ CSDOT/ ADDS 3/4
O.P.Code-19984 19/12/25

Q.3 a) A Data Science program has a prerequisite network among modules: (08M)

M1: Python Basics
M2: DS Foundation
M3: Machine Learning
M4: Deep Learning
M5: Deployment

Given relation R = {(1,2), (2,3), (3,4), (4,5), (1,1), (3,3), (5,5)}

i. Apply Warshall's Algorithm to compute transitive closure.
ii. For each Mi, list all modules it can unlock.
iii. Identify root modules and terminal modules.
iv. Explain how this helps curriculum planners maintain valid learning paths.

May 2026 · Q3a · 8 marks

Q.3 a) A domestic airline company maintains a directed flight network among four cities:

$$V = \{a, b, c, d\}$$

The direct flight connections are represented by the relation:

$$R = \{(a, b), (b, d), (d, c), (d, a)\}$$

The company wants to analyze all possible direct and indirect travel routes, including circular journeys.

Based on the given flight network:

1. Identify and explain the concept of **reachability / transitive closure** used in the graph.
2. Determine all possible ordered pairs of cities connected through:
   - direct routes,
   - routes with layovers, and
   - circular routes.
3. Analyze how graph connectivity helps optimize airline route planning.
4. Represent the final connectivity relation for the graph. (08M)

6. Partial Orders — Hasse Diagrams & Lattices

Dec 2025 · Q3b · 7 marks

Q.3 b) Data storage providers offer plans of sizes: **(07M)**
S = {1 TB, 2 TB, 4 TB, 8 TB, 16 TB}

Relation a | b (a divides b)

i. Draw the Hasse diagram.
ii. List all (a,b) where a divides b.
iii. Check whether S forms a lattice (meet & join for every pair).
iv. Explain impact on designing upgrade/downgrade recommendations and plan combinations in the storage app.

May 2026 · Q3b · 7 marks

b) A cloud access-control system organizes permission levels using divisibility-based hierarchy. The permission levels are:

$$A = \{1,2,3,6,12,24,36,72\}$$

A relation R is defined on A as:

$$(x, y) \in R \text{ if } x \mid y$$

Based on this hierarchy:

1. Write all ordered pairs of relation R.
2. Construct the **Hasse Diagram** of the poset.
3. Analyze whether the given poset forms a **lattice**.
4. Justify your answer using suitable meet and join examples. (07M)

7. Groups — Multiplication Tables & Inverses (mod 7)

Dec 2025 · Q4a · 8 marks

Q.4 a)A QR-based token system transforms token number a into: **(08M)**
T(a) = (a × k) mod 7, with a ∈ {1…6}.

i. Construct multiplication table ($\times_7$).
ii. Find modular inverses of 2, 3, 5 under mod 7.
iii. Determine if ({1…6}, $\times_7$) forms a group.
iv. Comment on whether this token transformation ensures reversibility, forgery prevention, and predictable validation.

May 2026 · Q4a · 8 marks

Q.4 a) A cryptographic system uses non-zero residue classes modulo 7 for secure key generation. Consider the set:

$$G = \{1,2,3,4,5,6\}$$

under multiplication modulo 7.

Based on this system:

1. Construct the multiplication table of G under multiplication modulo 7.
2. Determine the multiplicative inverses of 2,3,5,and 6.
3. Analyze whether G forms a cyclic group.
4. If it is cyclic, identify at least one generator and justify your answer.

8. Mathematical Induction

Dec 2025 · Q4b · 7 marks

Q.4 b) A student deposits savings in a fund according to: (07M)

Daily saving: $S_n = 4n - 1$

They want to verify if S_n is always odd for all natural numbers n.

i. Prove the statement using mathematical induction.

ii. Explain the meaning for planning weekly budgets and long-term savings.

May 2026 · Q4b · 7 marks

Paper / Subject Code: N2115112 / Discrete Structures and Graph Theory

SE-Sem III / NEP / MAY 2026 / Computers / APDS / CSIOT / Date- 06/06/2026

Q.P- 14827 3/4

b) A data analyst observes that the cumulative computational cost of a repeated process is modeled by the series:

$$\sum_{r=1}^{n} r(r+3)$$

The analyst claims that for every positive integer n,

$$\sum_{r=1}^{n} r(r+3) = \frac{1}{3}n(n+1)(n+5), n \geq 1, n \in \mathbb{N}$$

Using the **principle of mathematical induction**:

1. Verify the result for the base case.
2. Prove the inductive step.
3. Conclude that the formula is valid for all $n \geq 1$.
4. Interpret how induction helps validate formulas in algorithm analysis. (07M)

9. Graph Isomorphism

Dec 2025 · Q5a · 8 marks

Q.5 a) Two lab surveillance networks are modeled as undirected graphs: **(08M)**

Graph G_1 (Cameras A,B,C,D):

A: B, C
B: A, D
C: A, D
D: B, C

Graph G_2 (Cameras P,Q,R,S):

P: Q, R
Q: P, S
R: P, S
S: Q, R

SE/Sem-III/NEP/Dec-25/Computer/CS IOT/AIDS 4/4
Q.P. Code:- 99814 19/12/25

i. Determine whether G_1 and G_2 are isomorphic.
ii. If yes, provide the mapping.
iii. Explain how detecting isomorphic patterns helps in reusing surveillance layouts and minimizing storage of duplicate designs.

May 2026 · Q5a · 8 marks

Q.5 a) A computer networking company proposes two communication network layouts represented by graphs G_1 and G_2. The organization wants to verify whether both network structures provide the same connectivity pattern even though the device labels are different.

The graphs are represented as:

$$V(G_1) = \{A, B, C, X, Y, Z\}$$
$$E(G_1) = \{(A,X), (A,Y), (B,X), (B,Y), (C,Y)\}$$
$$V(G_2) = \{1,2,3,4,5,6\}$$
$$E(G_2) = \{(1,4), (1,5), (2,4), (2,5), (3,5)\}$$

Based on the above network structures:

1. Define **isomorphism of graphs**.
2. Analyze whether graphs G_1 and G_2 are **isomorphic**.
3. If they are isomorphic, determine a valid **one-to-one correspondence** between the vertices.
4. Justify your answer by comparing degree sequence and adjacency preservation. (08M)

10. Recurrence Relations

Dec 2025 · Q5b · 7 marks

Q.5 b) A student club records followers using recurrence: $F_n = 4F_{n-1} - 4F_{n-2}$ **(07M)**

With,

$F_0 = 10$ (core team)
$F_1 = 30$ (after first promotion)

i. Solve the recurrence relation.
ii. Describe growth pattern (linear/exponential).
iii. Comment whether such growth is realistic for a campus club in long term.

May 2026 · Q5b · 7 marks

b) A financial analytics company models the quarterly growth of a digital investment portfolio using a recurrence relation. Let F_n represent the portfolio value during the n^{th} quarter.
The growth pattern is governed by:

$$F_n = 3F_{n-1} + 10F_{n-2} + 7 \cdot 5^n$$

with initial conditions:

$$F_0 = 4, F_1 = -3$$

Based on this predictive model:
1. Solve the given recurrence relation using an appropriate method.
2. Determine the general expression for F_n.
3. Analyze the effect of the exponential forcing term $7 \cdot 5^n$ on the sequence growth.
4. Interpret how recurrence relations are useful in financial forecasting and computational modeling. (07M)

11. Rings — Z6 & Z4

Dec 2025 · Q6a · 8 marks

Q.6 a) The college uses modulo-6 operations to rotate lab batches: **(08M)**
Addition: $a \oplus b = (a + b) \bmod 6$
Multiplication: $a \otimes b = (a \times b) \bmod 6$

i. Check if $(Z_6, \oplus)$ is an abelian group.
ii. Check closure, associativity of $(Z_6, \otimes)$.
iii. Verify distributive property of $\otimes$ over $\oplus$.
iv. Conclude whether $(Z_6, \oplus, \otimes)$ forms a ring, and discuss why this matters in designing timetable rotation logic.

May 2026 · Q6a · 8 marks

QP-14827 (4/4)

Q.6 a) A cryptographic system uses arithmetic operations on residue classes modulo 4 for encoding and verification. Consider the set:

$$Z_4 = \{0,1,2,3\}$$

with addition and multiplication defined modulo 4.
Based on this algebraic structure:
1. Construct the addition and multiplication tables for Z_4.
2. Verify whether Z_4 satisfies the required ring properties.
3. Analyze the role of additive identity, additive inverse, multiplicative associativity, and distributive laws.
4. Conclude whether Z_4 forms a ring under addition and multiplication modulo 4. (08M)

12. Euler & Hamiltonian Paths / Circuits

Dec 2025 · Q6b · 7 marks

Q.6 b) A research conference venue is modeled as graph V = {A,B,C,D,E,F} with edges: **(07M)**
E = {AB, AC, BC, BD, CE, DE, DF, EF}

i. Determine existence of Euler Path, Euler Circuit, Hamiltonian Path, Hamiltonian Circuit.
ii. Construct them if they exist.
iii. Explain what this means for planning visitor flow, inspection rounds, and avoiding

b) A city transport authority is analyzing a road network connecting six important locations $A, B, C, D, E,$and F. The network is represented by the following graph:
Graph

Based on the given road network:

1. Determine whether the graph has an **Euler Path**.
2. Determine whether the graph has an **Euler Circuit**.
3. Determine whether the graph has a **Hamiltonian Path**.
4. Determine whether the graph has a **Hamiltonian Circuit**.
5. Justify your answer using degree of vertices and graph traversal conditions. (07M)

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THEORY QUESTIONS

Topic-wise · Dec 2025 + May 2026 · 2 questions

1. Equivalence Relations — Properties & Classes

Dec 2025 · Q1a · 5 marks

Attempt any three out of six sub questions.

Q.1 a) A student-feedback system groups teacher responses using the rule: **(05M)**
Two responses x and y are "similar" if they fall in the same satisfaction band (e.g., 1–2 = Low, 3 = Medium, 4–5 = High).
i. Using definitions of reflexive, symmetric, transitive, determine whether "similarity" is an equivalence relation.
ii. Explain the classroom-level meaning of each property.
iii. Discuss how violating any property affects AI-based feedback analytics and dashboard reports.

May 2026 · Q1a · 5 marks

Q. 1 a) A digital geometry learning platform groups polygons based on the number of sides for automatic classification and retrieval. Let A be the set of all polygons. A relation R is defined on A as:

$$R = \{(P_1, P_2): P_1 \text{ and } P_2 \text{ have the same number of sides}\}$$

Based on this classification system:

1. Analyze whether the relation R is an **equivalence relation** on A.
2. Verify the properties of **reflexivity, symmetry, and transitivity**.
3. Construct suitable equivalence classes for triangles, quadrilaterals, and pentagons.
4. Interpret how equivalence relations help organize geometric data in digital systems. (05M)

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