Tribhuvan University
Institute of Science and Technology
2065

✡

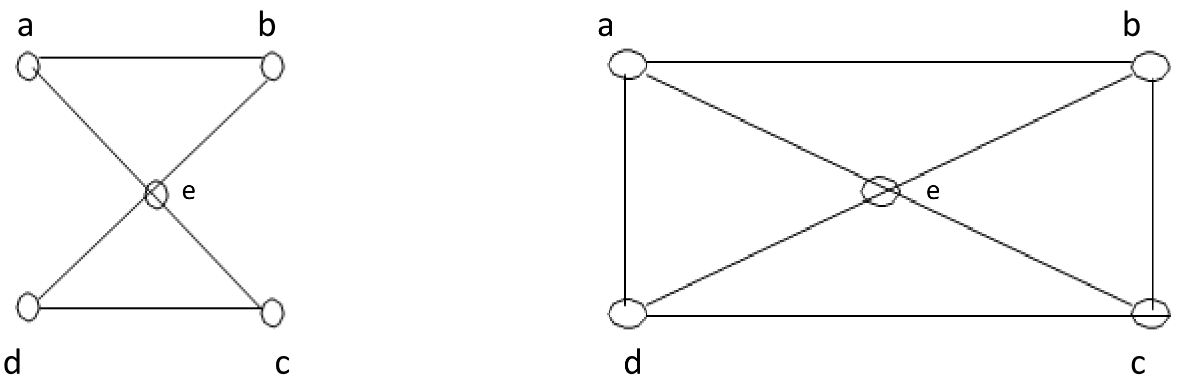
Bachelor Level/ First Year/ Second Semester/ Science — Full Marks: 80
Computer Science and Information Technology (CSC 152) — Pass Marks: 32
(Discrete Structure) — Time: 3hours

Candidates are required to give their answers in their own words as for as practicable.
The figures in the margin indicate full marks.

Attempt all questions:

Group A (10x2=20)

1. Given propositions p and q, define conjunction and disjunction of them.
2. Define existential quantifications with suitable examples.
3. State which rule of inference is basis of the following argument: "It is below freezing and raining now, therefore, it is below freezing now."
4. State and prove the Pigeonhole principle.
5. Define linear homogeneous recurrence relation.
6. Define the terms a language over a vocabulary and the phrase-structure grammar.
7. Distinguish between deterministic and nondeterministic finite state automaton.
8. Define the complete graph K_n on n vertices and the complete bipartile graph $K_{m,n}$ with suitable examples.
9. Which of the undirected graphs in the following figure have an Euler circuit? Explain.



10. What is the chromatic number of the complete bipartile graph $K_{m,n}$, where m and n are positive integers?

Group B (5x4=20)

11. Explain the 4 rules of inference for quantified statements.
12. Find an explicit formula for the Fibonacci numbers, with recursion relation $f_{n-1} + f_{n-2}$ and $f_0 = 0, f_1 = 1$
13. Define finite-state with output with suitable examples.

OR

Define deterministic finite state automata. When are two finite state automata equivalent? Give an example.

14. Show that the graphs in the following figure are not isomorphic.

What can you say about the complexity of graph isomorphism algorithms in terms of complexity?

15. Prove that an undirected graph is a tree if there is a unique simple path between any two of its vertices.

Group C (5x8=40)

16. Explain Tautologies, contradiction and contingencies with suitable examples.

OR

Explain the method of proving theorems by direct, indirect, contradiction and by cases.

17. Define linear homogeneous recursion relation of degree K with constant coefficient with suitable examples. What is the solution of the recurrence relation $a_n = a_{n-1} + 2a_{n-2}$ with $a_0 = 2$ and $a_1 = 7$?

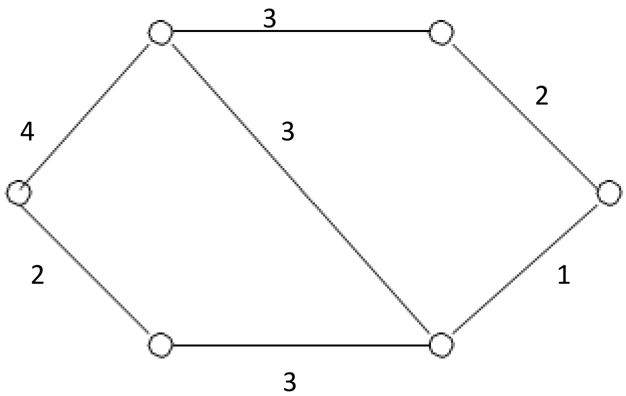
18. Let G be the grammar with vocabulary $V = \{S, 0,1\}$, set of terminals $T = \{0,1\}$, starting symbol S, and productions $P = \{S \rightarrow 11S,\ S \rightarrow 0\}$. What is L(G), the language of this grammar?

19. Explain the concept of network flows and max-flow min-cut theorem with suitable examples.

20. Define Euler and Hamiltonian circuits and paths with examples illustrating the existence and nonexistence of them.

OR

Discuss the shortest path algorithm of Dijkstra for finding the shortest path between two vertices. Use this algorithm to find the length of the shortest path between a and z in the following weighted graph?



Give the idea of travelling salesman problem and the difficulties of solving it.

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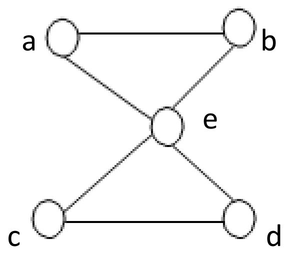
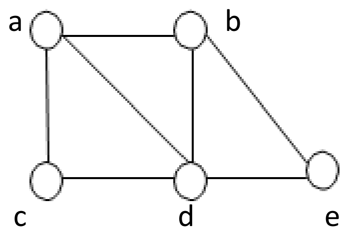
Attempt all questions:

Group A (10x2=20)

1. Define proposition and its negation with an example.
2. Show that ¬ (p V q) and ¬p∧ ¬q are logically equivalent.
3. State which rule of inference is the basis of the following argument; "It is below freezing now. Therefore, it is either below freezing or raining now."
4. State the Pigeonhole principle. How many students must be in class to guarantee that at least two students receive the same score on the final exam is graded on a scale from 0 to 100?
5. Let $\{a_n\}$ be a sequence that satisfies the recursion relation $a_n = a_{n-1} - a_{n-2}$ for $n \geq 2$ and suppose that $a_0 = 3$ and $a_1=5$. Find the values a_2 and a_3.
6. Let G be the grammar with vocabulary V = {S, A, a, b}, t = {a, b}, starting symbol S and production P = {S⟶ aA, S⟶ b, A⟶ aa}. What is L(G), the language of this grammar ?
7. Determine the kleen closures of the sets A = {0}, B = {0, 1}, C = {11}.
8. How many edges are there in graph with 10 vertices each of degree six?
9. Which of the undirected graphs in the following have an Euler path?





10. Determine the chromatic number K_n.

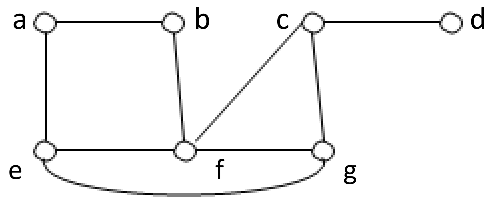
Group B (5x4=20)

11. Differentiate between existential and universal quantifiers with suitable examples.
12. Find the solution of the recursion relation $a_n = a_{n-1} + 2a_{n-2}$ with $a_0 = 2$ and $a_1=7$?

    OR

    Find an explicit formula for the Fibonacci numbers.
13. Define deterministic finite state automata. Construct a DFA whose language is the set of strings that ends with 111 and contains odd number of 1's.
14. Prove that an undirected graph is a tree if and only if there is a unique simple path between any two of its vertices.

15. Find a spanning tree of the simple graph in the following graph, if it exists.



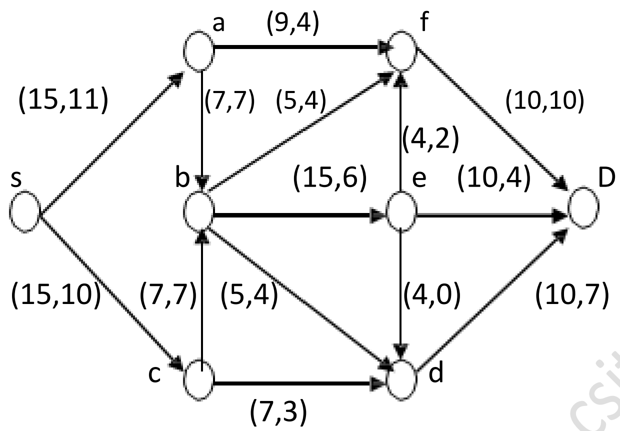
Can there be more possibilities?

Group C **(5x8=40)**

16. Discuss the techniques of proofs by contradiction and by cases with suitable examples.
17. Describe linear homogeneous and linear non-homogeneous recurrence relations with suitable examples.
18. Explain non-homogeneous finite automata and language of NFA with suitable example.
19. State and prove the Max-flow and Min-cut theorem.

OR

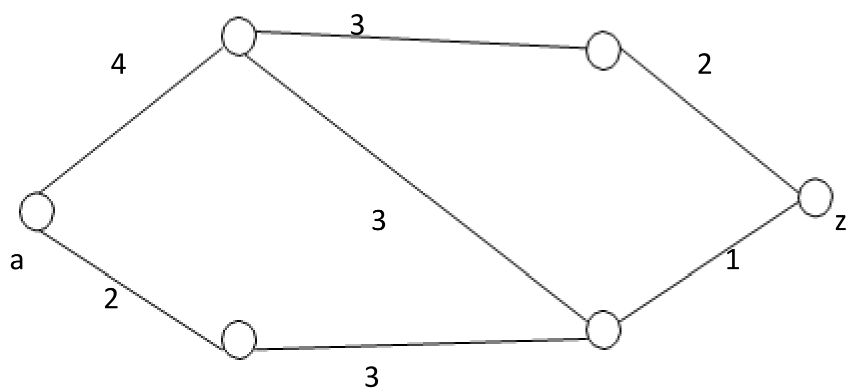
Find a maximum flow for the network in the figure below.



20. Define Hamiltonian paths and circuits with suitable examples for the existence and nonexistence. Show that has a Hamilton circuit whenever .

OR

Write the shortest path algorithm of Dijkstra for finding the shortest path between two vertices. What is the length of shortest path between a and z in the weighted graph in the following figure?



Apply the stated algorithm for finding the solution.

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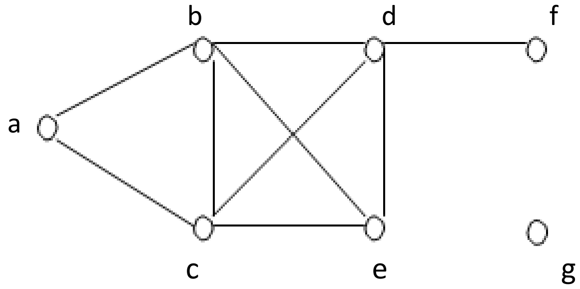
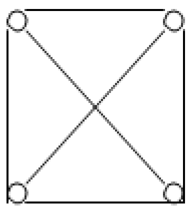
Attempt all questions:

<u>Group A</u> (10x2=20)

1. What do you mean by proposition? Give example to justify your answer.
2. How do you define logically equivalent propositions?
3. Give examples of addition rule and simplification rule of inference.
4. State and prove the Pigeonhole principle.
5. How many ways are there to select a first, second and third – prize winners from 10 different people?
6. Discuss the types of phrase structure grammars and their relations.
7. Give formal definition of regular expressions over a set I.
8. Verify the Handshaking theorem in the figure.



9. Is the graph K_4 planar? How?



10. Determine the chromatic number K_n.

<u>Group B</u> (5x4=20)

11. Explain the 2 rules of inference for quantified statements and give suitable examples.

OR

Show that the propositions $p \vee (p \wedge r)$ and $(r \vee q) \wedge (p \vee r)$ are logically equivalent.

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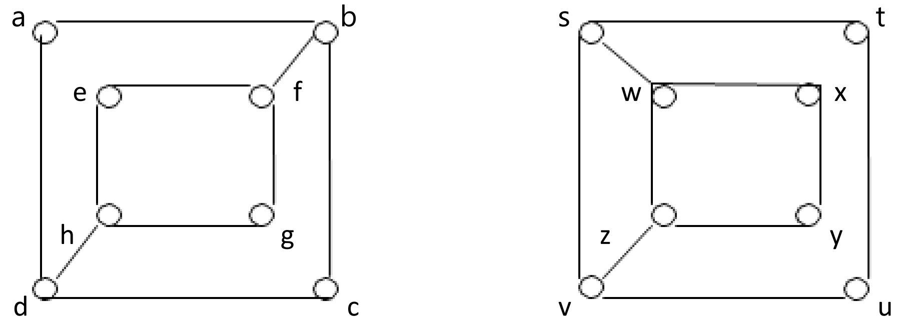
12. Define the binomial coefficient and give the general term of the binomial coefficient. Show that the sum of the binomial coefficient is 2^n.

13. How do you distinguish deterministic and nondeterministic finite-state automaton? Give suitable examples.
14. Determine whether the graphs shown in the following figure are isomorphic.



What can you say about the graph isomorphism algorithms in terms of efficiency?

15. Prove that a tree with n-vertices has n-1 edges.

Group C (5x8=40)

16. Discuss the techniques of direct proof indirect proof and vacuous proof for proving implications with suitable examples.

17. Find the solution to the recursion relation

$$a_n = 6a_{n-1} - 11a_{n-2} + 6a_{n-3}$$

with initial conditions $a_0 = 2$, $a_1 = 5$ and $a_2 = 15$.

OR

Suppose that a person deposits Rs.10,000/- in a fixed account at a bank yielding 11% per year with interest compounded annually. How much will be in the account after 10 years? Solve the problem with modeling it into recursion relations.

18. What do you mean by phase-structure grammar? Let C_1 be the grammar with vocabulary V = {S, 0, 1}; set of terminals T= {0, 1}; starting symbol S, and productions P= {S→11s, S→0}. Determine the language L(G) of this grammar.

19. Explain the concept of network flows and max-flow min-cut theorem with suitable examples.

OR

Define Euler circuit and Euler path with suitable examples. Give the multi-graph model of the two of Koenigsberg state a necessary and sufficient condition for Euler circuit in connection to your definitions and models.

20. Discuss the Algorithm of Dijkstra for finding the shortest path in a weighted graph between two vertices with suitable example. Moreover, explain the travelling salesman problem and the efficiency of algorithm for solving this problem.

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Attempt all questions:

Group A (10x2=20)

1. Define disjunction and conjunction with suitable examples.
2. Is the following argument valid?
   Smoking is healthy.
   If smoking is healthy, then cigarettes are prescribed by physicians.
   ∴Cigarettes are prescribed by physicians
3. State the rules for the strong form of mathematical induction with propositions.
4. State and prove “the extended pigeonhole principle”.
5. Define the terms a language over a vocabulary and the phrase – structure grammar.
6. Distinguish between binary tree and spanning tree with suitable examples.
7. Consider K_n, the complete graph on n vertices. What is the degree of each vertex?
8. Explain the static transition function of the finite state machine with a suitable table.
9. Define regular expression over a non-empty set A.
10. What is the chromatic number of the complete bipartite graph, where m and n are positive integers?

Group B (5x4=20)

11. Explain the rules of inference for quantified statements.
12. Let A = {p, q, r}. Give the regular set corresponding to the regular expression given:
    a) (p v q) ┌ q* b) p(q q)* r.
13. Find an explicit formula for the Fibonacci sequence defined by

$$f_n = f_{n-1} + f_{n-2}\,, \quad f_1 = f_2 = 1$$

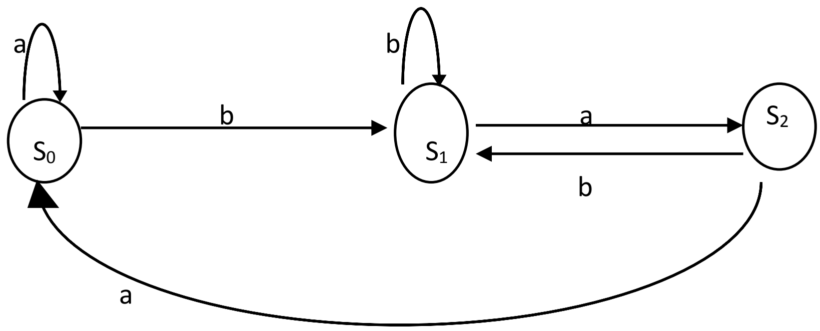
14. Define finite – state machines with output.
15. Show that the maximum number of vertices in a binary tree of height n is $2^{n+1} - 1$.

OR

Draw all possible unordered trees on the set {a, b, c}.

Group C (5x8=40)

16. Construct the transition table of the finite – state machine whose diagraph is shown?



17. Let G = (V, S, v_0, |→), where V = { v_0, x, y, z}, S = {x, y, z } and

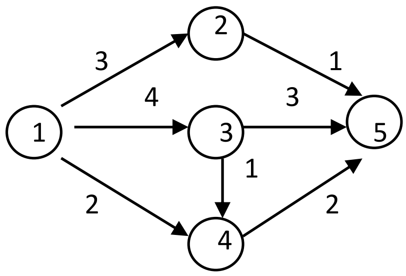
|→ : v_0 |→ xv_0

v_0 |→ yv_0

v_0 |→ z

What is L(G), the language of this grammar?

18. Find a maximum flow in the network shown in figure

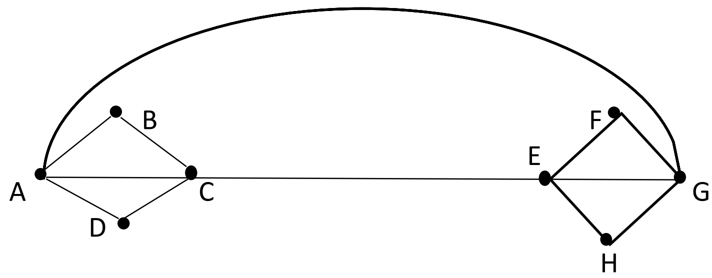


19. Prove that a symmetric connected relation has a undirected spanning tree.

OR

Give a simple condition on the weights of a graph that will guarantee that there is a unique maximal spanning tree for the graph.

20. Use Fleury's algorithm to construct an Euler circuit for the following graph.



OR

Explain the concept of network flows and max-flow min- cut with suitable examples.

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Attempt all questions:

Group A (10x2=20)

1. Given propositions p and q, define conjunction and disjunction of p and q.
2. Is the following argument valid?

   If taxes are lowered, then income rises.
   Income rises.
   ___
   ∴ **Taxes are lowered**

3. Use mathematical induction to prove that $4^n - 1$ is divisible by 3.
4. State and prove "the pigeonhole principle".
5. Develop a "general explicit formula" for a nonhomogeneous recurrence relation of the form:

   $a_n = rq_{n-1} + s$, where s and r are constants.

6. Define the terms a language over a regular grammar and a regular expression.
7. Distinguish between multi graph and pseudo graph with suitable examples.
8. Let A = {0, 1}. Show that the following expressions are all regular expressions over A
   a) 0* (0v1)*　　b) 00* (0v1)* 1.
9. Distinguish between undirected and directed graphs with illustrations.
10. Explain non-deterministic finite state automata.

Group B (5x4=20)

11. Let S = {0, 1}. Give the regular expression corresponding to the regular set given:
    a) {00, 010, 0110, 011110, …}
    b) {0, 001, 000, 00001, 00000, 0000001, …}
12. For the Fibonacci sequence, prove that for n ≥ 2.

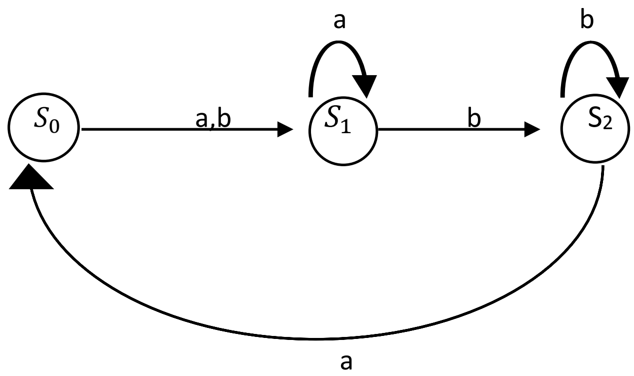
    $$f_{n+1}^2 - f_n^2 = f_{n-1} \ f_{n-2}$$

13. Define explicit formula for the sequence: {a1, a2, a3,….}. Write an explicit formula for the sequence 2, 5, 7, 12, 19, 31.
14. Explain the rules of inference for quantified statements.
15. Define isomorphism. Given an example to show that the graphs are not isomorphic.

Group C (5x8=40)

16. Define deterministic finite state automata. When are two finite state automata equivalent? Explain it.

17. Construct the state transition table of the finite state machine whose diagram is shown:



18. Construct truth tables to determine whether the given statement is a tautology, a contingency, or an absurdity:

    a) $p \Rightarrow (q \Rightarrow p)$

    b) $q \Rightarrow (q \Rightarrow p)$

    c) $p \wedge \sim p$

19. A phrase structure grammar g is defined to be a 4-tuple (V, S, v_0 $|\rightarrow$), where V=(v_o, w, a, b, c}, S={a, b, c}, $v_o \mid\rightarrow aw$, $w \mid\rightarrow bbw$, $w \mid\rightarrow c$. Derive a sentence of L(G), the language of this grammar.

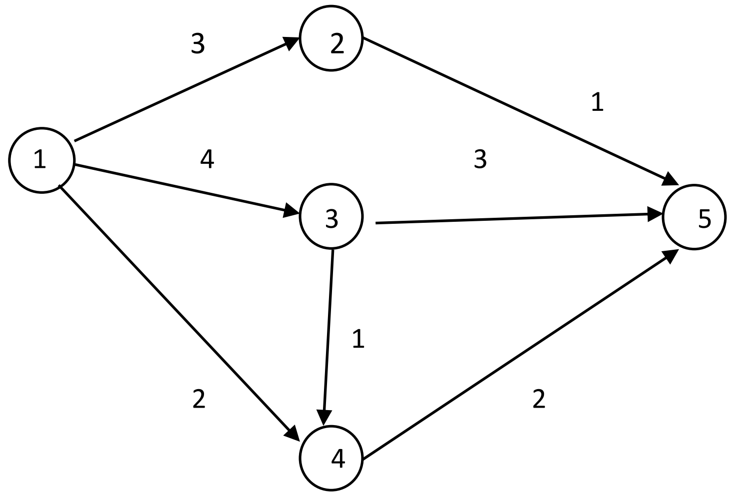
OR

Prove that an undirected graph is a tree if and only if there is a unique simple path between any two of its vertices.

20. Explain the concept of network flows and Max-flow Min-cut theorem with suitable examples.

OR

Find a maximum flow in the network shown in the figure.



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Group A (10x2=20)

1. What is compound proposition? Discuss implication with suitable example.
2. Which rule of inference is used in the following argument?
   Ram is hard working. If Ram is hard working, then he is intelligent. Therefore Ram is intelligent.
3. What is the coefficient of $x^{12} y^{13}$ in the expansion of $(2x – 3y)^{25}$?
4. Is the sequence $\{a_n\}$ a solution of the recurrence relation $a_n = -3a_{n-1} + 4a_{n-2}$ if $a_n = 2n$?
5. Define linear homogeneous recurrence relation of degree k with constant coefficients.
6. What is phrase-structure grammar?
7. What is regular expression?
8. What is chromatic number of a graph?
9. What is spanning tree?
10. State max-flow min-cut theorem.

Group B (5x4=20)

11. How many bit strings of length eight either start with a 1 bit or end with two bits 00?
12. Discuss the importance of recurrence relations in the analysis of divide-and-conquer algorithms.
13. Let G be the grammar with vocabulary V = {S, 0, 1}, set of terminals T= {0, 1}; starting symbol S, and productions P= {S→11s, S→0}. Determine the language L(G) of this grammar.
14. Discuss adjacency matrix representation of a graph with suitable example.
15. Prove that “a simple graph is connected if and only if it has a spanning tree”.

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Group C (5x8=40)

16. What is mathematical induction? Use mathematical induction to prove that
    $1.1! + 2.2! + \ldots + n.n! = (n+1)! - 1$, wherever n is a positive integer.

17. Solve the recurrence relation $a_n = 2a_{n-1} + 2a_{n-2} + 2a_{n-3}$ for $n \geq 3$, $a_0 = 3$, $a_1 = 6$ and $a_2 = 9$.

    OR

    Find the explicit formula for the Fibonacci numbers. Use $f_n = f_{n-1} + f_{n-2}$ as recursive condition and $f_0 = 0$ and $f_1 = 1$ as initial condition.

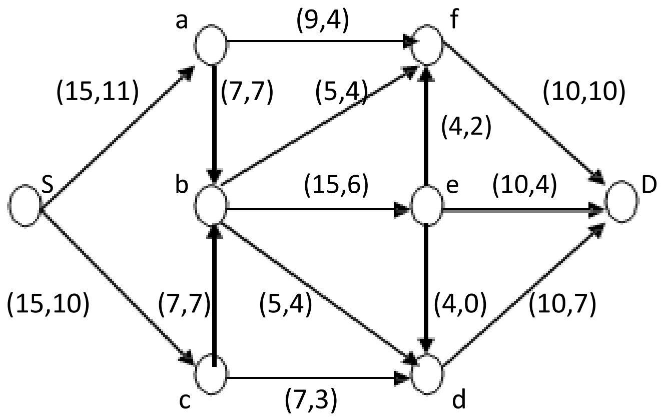
18. Discuss finite state machine without output with suitable example. What are the strings in the regular set specified by the regular expression 0* 1*?

19. Define an Euler circuit and Euler path in an undirected graph. How can it be determined whether an undirected graph has an Euler circuit and an Euler path? Explain with suitable example.

20. Define maximal flow and minimal cut and state and prove min-cut max-flow theorem.

    OR

    Find a maximal flow for the network shown in the figure below:



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TRIBHUVAN UNIVERSITY
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Attempt all questions:

<u>Group A</u> (10x2=20)

1. What is negation? Discuss with suitable example and truth table.
2. Discuss universal quantifier with example.
3. Define universal instantiation.
4. How many different license plates is available if each plate contains sequence of three letters followed by three digits?
5. How many students must be in a class to guarantee that at least two students receive the same score on the final exam, if the exam is graded on a scale from 0 to 100 points?
6. Define cut vertices and cut edges.
7. Suppose that a planar simple graph has 20 vertices, each of degree 3. Into how many region does a representation of this planar graph split the plane?
8. What is minimal cut?
9. What are the strings in the regular sets specified by the regular expression (10)*.
10. Let G be the grammar with vocabulary V = {S, 0, 1}, set of terminals T = {0, 1}, starting symbol S, and productions $P = \{S \rightarrow 11S, S \rightarrow 0\}$. What is L (G), the language of this grammar?

<u>Group B</u> (5x4=20)

11. Use mathematical induction to prove that the sum of the first n odd positive integers is n^2?

    OR

    Discuss Modus Ponens with suitable example.
12. What is binomial theorem? Use this theorem to find the coefficient of $x^{12} y^{13}$ in the expansion of $(2x - 3y)^{25}$.
13. Show that $K_{3,3}$ is not planar?

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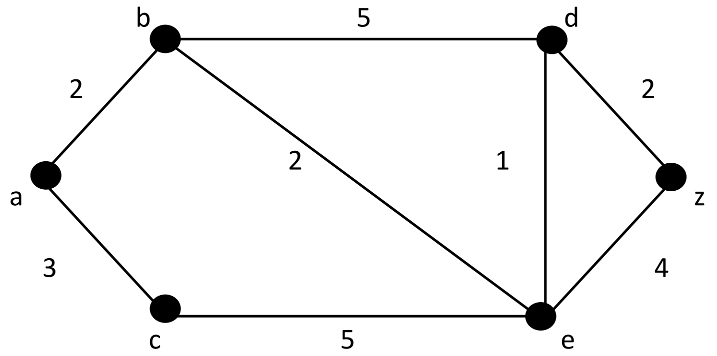
14. Show that a tree with n vertices has n-1 edges.
15. Construct a nondeterministic finite-state automaton that recognizes the regular set $1^* \cup 01$.

Group C (5x8=40)

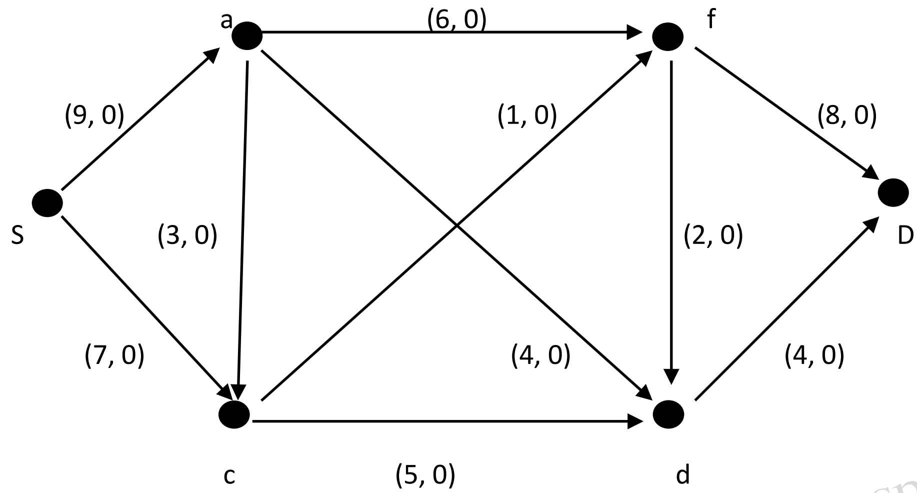
16. Discuss direct proof, indirect proof, and proof by contradiction with suitable example.
17. What is shortest path problem? Find the length of a shortest path between a and z in the given weighted graph.



18. Find the recurrence relation to find the number of moves needed to solve the TOH (Tower of Hanoi) problem with n disks. Discuss application of recurrence relation in divide-and-conquer algorithms.

19. An undirected graph is a tree if and only if there is a unique simple path between any two of its vertices.

20. Find a maximal flow for the network shown in the figure below:



TRIBHUVAN UNIVERSITY

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Candidates are required to give their answers in their own words as far as practicable.
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Attempt all questions:

Group A (10x2=20)

1. What is conjunction? Discuss with suitable example and truth table.
2. Show that $(p \wedge q) \to p$ is a tautology by using truth table.
3. What is valid argument?
4. In how many ways we can draw a heart or a diamond from an ordinary deck of playing cards?
5. What is pigeonhole principle?
6. Show that an undirected graph has an even number of vertices of odd degree.
7. What is minimum spanning tree?
8. Define saturated edge in a transport network.
9. What is a phrase-structure grammar?
10. What are the strings in the regular sets specified by the regular expression 10*.

Group B (5x4=20)

11. What is logical equivalence? Show that $p \to q$ and $\neg q \to \neg q$ are logically equivalent.

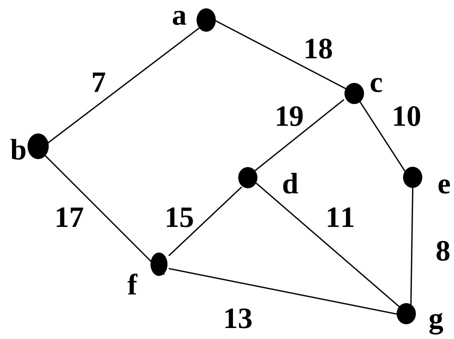
OR

Discuss Modus Ponens with suitable example.

12. Discuss the principles of inclusion-exclusion. How many bit strings of length eight either start with a 1 bit or end with two bits 00?
13. What is graph isomorphism? What are the different invariants of graph isomorphism?
14. Discuss adjacency matrix representation of graph with example.
15. Let G be the grammar with vocabulary V = {S, 0, 1}, set of terminals T = {0, 1}, starting symbol S, and production $P = \{S \to 11S, S \to 0\}$. What is the L(G) of this grammar?

Group C (5x8=40)

16. Discuss the different rules of inference for quantified statements along with suitable example of each.
17. Find all the solutions of the recurrence relation $a_n = 4a_{n-1} + n^2$. Also find the solution of the relation with initial condition $a_1 = 1$.
18. Discuss the algorithm for constructing Euler circuit with suitable example.
19. Discuss Kruskal's algorithm for constructing a minimum spanning tree. Use this algorithm to find minimum spanning tree in the graph given below.



20. State and prove Max-Flow Min-Cut theorem.