

**MASTER OF COMPUTER APPLICATIONS
(MCA-NEW)**

Term-End Examination

June, 2022

MCS-212 : DISCRETE MATHEMATICS

Time : 3 hours

Maximum Marks : 100

Note : Question no. 1 is **compulsory** and carries 40 marks. Attempt any **three** questions from questions no. 2 to 5.

1. (a) Write the mathematical notation for the following : 4
- (i) The set of all odd numbers
- (ii) The set of all natural numbers whose square is more than 26
- (b) Assuming that p and q are two propositions, find if the following two statements are logically equivalent or not, by constructing the truth table. 5

$$\sim (p \vee q) \vee \sim q \text{ and } (p \vee \sim q) \vee q$$

- (c) Use the principle of mathematical induction to prove that

$$1 + 2 + 3 + \dots + n = \frac{n(n+1)}{2} \text{ for each } n \in \mathbb{N}. \quad 5$$

- (d) Define the term regular expression with the help of an example. 5

- (e) How many different permutations are possible of the letters, taken all at a time, of the word : ASSESSES ? 3

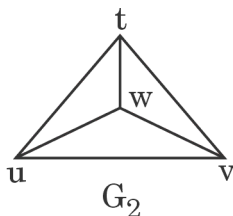
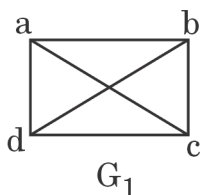
- (f) A die is rolled once. What are the probabilities of the following events : 4

- (i) Getting an odd number
- (ii) Getting at least a value 2
- (iii) Getting at most a value 2
- (iv) Getting at least 7

- (g) Define the problem of the Tower of Hanoi. Explain the recurrence relation to solve this problem. 6

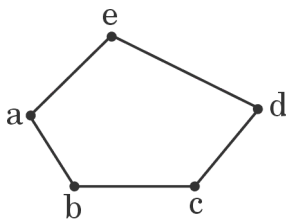
- (h) Draw a hypercube graph Q_3 (also called the cubical hypercube). 3

- (i) Find, if the following graphs G_1 and G_2 are isomorphic or not. Explain how you arrived at your answer. 5



2. (a) Define the degree and order of a recurrence relation. Find the degree and order of the following recurrence relations : 6
- (i) $a_n = a_{n-1}^2 + a_{n-2} a_{n-3} a_{n-4}$
- (ii) $a_n = na_{n-2} + 2^n$
- (b) What is a finite automata ? Why is it needed ? How is a finite automata represented ? Explain with the help of an example. 8
- (c) What is divide-and-conquer approach ? Explain how this approach can be used to apply binary search in a sorted list. 6
3. (a) What is proposition ? Explain with the help of an example. Explain Disjunction and Conjunction with the help of truth table for each. 6
- (b) Prove the following theorem by direct proof method :
 “The square of an even integer is an even integer.” 6
- (c) Given the Boolean expression $(a' \vee (b \wedge c')) \wedge (b \vee d')$, draw the corresponding circuit, where a, b, c and d are the inputs to the circuitry. 8

4. (a) Show the intersection and difference operation on two sets using Venn diagram. 4
- (b) Define the terms Domain, Co-domain and Range in the context of a function. Also find the domain, co-domain and range for a function A to B , where $A = \{1, 2, 3, 4\}$ and $B = \{1, 4, 9, 16, 25\}$. 6
- (c) A committee consisting of 2 male and 2 female workers is to be constituted from 8 male and 9 female workers. In how many distinct ways can this be done ? 4
- (d) Show, using the pigeonhole principle, that in any group of 30 people, 5 people can always be found who were born on the same day of the week. 3
- (e) Find how many of the four digit numbers are even. 3
5. (a) Define the following in the context of graph, with the help of an example : 6
- Complete graph
 - Star topology
 - Degree of a vertex
- (b) Find the complement of the following graph : 5

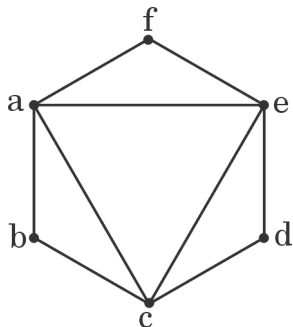


(c) What is a bipartite graph ? Explain with the help of an example.

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(d) Differentiate between Eulerian graph and Eulerian circuit. Find the Eulerian circuit in the following graph, if it exists.

5



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December, 2022

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Time : 3 Hours

Maximum Marks : 100

Weightage : 70%

Note : (i) *Question No. 1 is compulsory*

(ii) *Attempt any **three** questions from the rest.*

1. (a) Differentiate between predicate and proposition. Also, write De Morgan's laws for both. 5
- (b) Use De Morgan's law to derive AND gate from NOR gate. 5
- (c) Explain the conditions for a relation to be an equivalence relation. 5
- (d) Prove that $S^* = (S^*)^* = S^{**}$, where S is a set of strings. 5

(e) Briefly discuss non-deterministic Turing machine. 5

(f) What is addition principle ? Use addition principle to solve the following case : 5

“Say there are three political parties P_1, P_2 and P_3 having 4, 5 and 6 members respectively.” In how many ways we can select two persons from same party to become President and Vice President ? 5

(g) What is power set ? Find the power set for the following given sets : 5

$$A : \{0, 1, 3, 5\}$$

$$B : \{\phi, A, B, C, E\}$$

(h) Briefly discuss Pigeon hole principle with suitable example. 5

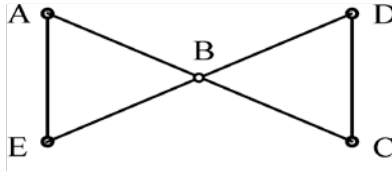
2. (a) Using induction, verify : 5

$$\sqrt{5}f_n = \left[\frac{1 + \sqrt{5}}{2} \right]^n - \left[\frac{1 - \sqrt{5}}{2} \right]^n \quad n \geq 1$$

(b) Define “Stirling number of the second kind.” Calculate S_3^2 and S_4^2 . 5

(c) Explain Handshaking theorem with suitable example. 5

- (d) What is a spanning tree ? Can we have a unique spanning tree ? Draw three spanning trees for the graph given below : 5



3. (a) For any two propositions x and y , verify that : 5

$$\sim(x \vee y) = \sim x \wedge \sim y$$

- (b) Find the number of three-letter words that can be formed using the letters of the English alphabet. How many of them end in 'x' ? How many of them have a vowel in the middle position ? 7

- (c) What is regular expression ? Find a regular expression to describe each of the following languages : 2+3+3

- (i) $\{a, b, c\}$
 (ii) $\{\wedge, a, abb, abbbb, \dots\}$

4. (a) Differentiate between the following : 10

- (i) Deterministic finite automata and Non-deterministic finite automata
 (ii) Moore machines and Mealy machines

- (b) Briefly discuss the Halting problem. 5

- (c) A box contains 3 red, 3 blue and 4 white balls. In how many ways can 8 balls be drawn out of the box, one at a time provided order is important ? 5
5. (a) Determine the recurrence relation and iterative relation for the power set $p(S)$ of set 'S'. 10
- (b) Write short notes on the following : $2 \times 5 = 10$
- (i) Path in a graph
 - (ii) Circuits in a graph
 - (iii) Cycles in a graph
 - (iv) Degree of vertex
 - (v) Regularity of graph

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Note : (i) *Question No. 1 is compulsory*

(ii) *Attempt any **three** questions from the rest.*

1. (a) Verify that $a \wedge b \wedge \sim a$ is a contradiction and $(a \rightarrow b) \leftrightarrow (\sim a \vee b)$ is a tautology. 5
- (b) Reduce the Boolean expression $(X_1 \wedge X_2) \wedge (X_1 \wedge X_2')$ to its simplest form. 5
- (c) Find inverse of the function $f(x) = x^3 - 3$. 5
- (d) What is Kleene closure ? Find Kleene closure for $\Sigma = \{0, 1\}$. 5

- (e) What is multiplication principle ? Use it to find the number of ways to choose two persons as President and Vice President from a party of 35 members. 5
- (f) Briefly discuss Inclusion-Exclusion principle with suitable example. 5
- (g) What is Eulerian graph ? Explain with the help of a suitable diagram. 5
- (h) What is Tautology ? Show that the given expression is a tautology : 5

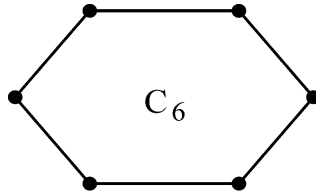
$$[(p \rightarrow q) \wedge \sim q] \rightarrow \sim p.$$

2. (a) Using induction, show that : 5

$$T_n = 2^n - 1, \quad n \geq 1.$$

- (b) In how many ways can 20 employees be assembled into 3 groups ? 5
- (c) Explain isomorphic graphs with suitable example. 5

- (d) What are Bipartite graphs ? Show that C_6 is a Bipartite graph : 5



3. (a) Check whether $(\sim p \vee q)$ and $(p \rightarrow q)$ are logically equivalent. 5
- (b) What is chromatic number of a graph ? Draw a graph with chromatic number 5. 5
- (c) Write short notes on the following : 10
- (i) Hamiltonian Graph
 - (ii) Vertex Cover Problem
4. (a) Show that the number of words of length 'n' on an alphabet for 'm' letters is m^n . 5
- (b) Construct the logic circuit and truth table for the given expression : 5+5
- $$x_1 \vee (x'_2 \wedge x_3) .$$
- (c) Given two switches, a battery and bulb design the Boolean circuit for AND gate and OR gate. 5

5. (a) Briefly discuss the following with suitable example for each : 5
- (i) Finite Automata
 - (ii) Regular expression
- (b) Differentiate between Turing Acceptable Language and Turing Decidable Language. 5
- (c) If C_n is the number of comparisons required to sort a list of n integers, determine the recurrence relation and iterative relation for C_n . 10

No. of Printed Pages : 6

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Note : *Question No. 1 is compulsory and carries 40 marks. Attempt any **three** questions from the rest four questions (Question Nos. 2 to 5).*

1. (a) Apply the precedence rules and write the truth table for the expression

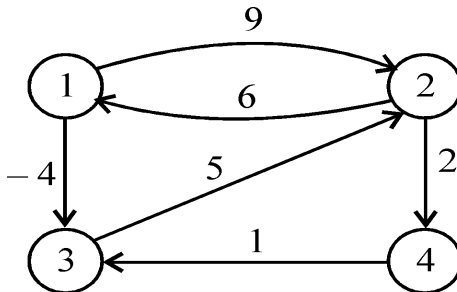
$$p \rightarrow q \wedge \sim r \leftrightarrow r \oplus q.$$

4

P. T. O.

- (b) Show that $[(p \rightarrow q) \wedge \sim q] \rightarrow \sim p$ is a tautology, without using truth table. 4
- (c) What is Dynamic Programming ? Write *four* major steps involved in dynamic programming. 4
- (d) Explain Conjunctive Normal Form (CNF) with a suitable example. 4
- (e) Find inverse of the function $f(x) = \frac{x-2}{x-3}$. 4
- (f) What is Kleene closure ? Write Kleene closure for the following set of alphabets : 4
- (i) $\Sigma = \{aa, b\}$
 - (ii) $\Sigma = \{a, ba\}$
- (g) What is a Turing machine ? Discuss the elements of the six tuple form of the Turing machine (Half State Version). 4
- (h) Suppose A and B are mutually exclusive events such that $P(A) = 0.3$ and $P(B) = 0.4$. What is the probability that : 4
- (i) A or B occurs
 - (ii) Either A or B does not occur ?

- (i) State Pigeonhole principle and Inclusion-Exclusion principle. 4
- (j) Write and prove the Handshaking theorem. 4
2. (a) Write down the statement “If it is raining and the rain implies that no one can go to play the match, then no one can go to play the match” as a compound proposition. Show that this proposition is a tautology, by using the principles of logical equivalence. 7
- (b) Write Floyd Warshall’s algorithm and apply it to find the shortest path for the graph given below (starting from vertex 1) : 8



- (c) Realize Conjunction, Disjunction and Negation (*i.e.* AND, OR and NOT) operation using switches. Also write truth table for each. 5
3. (a) If A is a set with n elements, then prove that $|P(A)| = 2^n$, where $P(A)$ is power set of A . 5
- (b) Compare Moore and Mealy machines. 5
- (c) What is Turing Machine ? Explain the working of the constituent components of the Turing machine with the help of a block diagram. 10
4. (a) Suppose we have three teams T_1 , T_2 and T_3 . Team T_1 has 4 members, T_2 has 5 members and T_3 has 6 members in a competition. Suppose we want to select two persons from the same team, to become captain and vice-captain for each team. In how many ways this can be done ? 5

- (b) Suppose 5 points are chosen at random within or on the boundary of an equilateral triangle of side 1 metre. Use Pigeonhole principle to show that we can find two points at a distance of at most $1/2$ metre. 5
- (c) Discuss the application of Inclusion-Exclusion principle for finding the number of derangements with a suitable example. 5
- (d) Given the recurrence relation $C_n = C_{n-1} + (n-1)$ with boundary condition $C_2 = 1$, show that $C_n = \frac{n(n-1)}{2}$, where C_n is the number of comparisons required to sort a list of n integers. 5
5. Explain any *five* of the following with suitable example for each : $5 \times 4 = 20$
- (i) Bipartite graph and its applications

- (ii) Circuits and cycles in a graph
- (iii) Edge connectivity and Edge traceability
- (iv) Hamiltonian graph and Ore's criterion
- (v) Travelling salesman problem
- (vi) Planar graphs

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Note : *Question No. 1 is compulsory and carries 40 marks. Attempt any **three** questions from the rest four questions (Question Nos. 2 to 5).*

1. (a) Apply precedence rules and write truth table for the expression : 4

$$p \oplus q \wedge r \rightarrow \sim p \vee q \leftrightarrow p \wedge r.$$

P. T. O.

- (b) Compare predicate logic with proposition logic and write De' Morgan's laws for both.

4

- (c) Show that :

$$(p \rightarrow q) \wedge (p \rightarrow \sim r) \equiv \sim (p \wedge (q \vee r)),$$

without using truth table. 4

- (d) Write principle of optimality. Also, give the satisfiability condition for the principle of optimality. 4

- (e) Explain Disjunctive Normal Form (DNF) with a suitable example. 4

- (f) Given $f(x) = \frac{1}{x}$ and $g(x) = x^3 + 2$, find

$$(fg)(x) \text{ and } \left(\frac{f}{g}\right)(x). \quad 4$$

- (g) What is a regular expression ? Write the rules to develop a regular expression. 4

- (h) Briefly discuss the Turing Acceptable language and Turing Decidable language. 4

- (i) Suppose we want to choose two persons from a company consisting of 35 persons, as Chairman and Vice-Chairman. In how many ways this can be done. 4
- (j) Using induction, show that $T_n = 2^n - 1$ ($n \geq 1$) is the iterative expression for the recursive expression $T_n = 2T_{n-1} + 1$ with $T_1 = 1$. 4
2. (a) Represent the following propositions and their negations using logical quantifiers. Also interpret their negation in words : 8
- (i) The magician can fool all the people all the time.
- (ii) Every real number is the square of some real number.
- (iii) There is a lawyer who never tells lie.
- (b) Write pseudo-code for Floyd Warshall's Algorithm (FWA). Discuss its working strategy with suitable example. Also, discuss the case when FWA gives the best result. 7

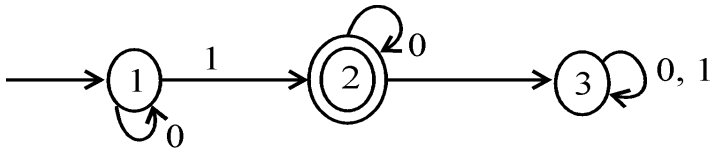
- (c) Draw the logical circuit for the expression :

$$(X'_1 \wedge X_2 \wedge X'_3) \vee ((X'_2 \vee X_1) \wedge X_3)$$

Also draw the truth table for the above expression. 5

3. (a) Differentiate between function and relation. Is every relation a function ? Justify with a suitable example. 5

- (b) Draw state transition table for the finite automata given below : 5



Also find the regular expression acceptable by the given finite automata.

- (c) Write short notes on the following : 10
- (i) Undecidable problem
 - (ii) Halting problem

4. (a) Suppose there are five married couples and they (10 people) are made to sit about a round table so that neither two men nor two women sit together. Find the number of such circular arrangements. 5
- (b) Give any *ten* different positive integers less than 107, use pigeonhole principle to show that there will be two disjoint subsets with the same sum. 5
- (c) What are surjective functions ? Discuss the application of inclusion-exclusion principle to the surjective functions. 5
- (d) Given the recurrence relation $S_n = 2S_{n-1}$ with $S_0 = 1$, show that $S_n = 2^n, n \geq 0$. 5
5. Write short notes on any *five* of the following :

$$5 \times 4 = 20$$

- (i) Isomorphic graphs and conditions of isomorphism

- (ii) Subgraph and spanning subgraph
- (iii) Path and circuits in a graph
- (iv) Eulerian Graph and Eulerian Circuit
- (v) Hamiltonian Graph and Dirac's criterion
- (vi) Map colouring problem