

Computer Science & IT

DRDO Scientist B PYQ

2020 Paper 1



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1. Consider the matrix

$$\mathsf{A} = \begin{pmatrix} 1 & 1 & 1 \\ 1 & 2 & 4 \\ 1 & 4 & 10 \end{pmatrix}$$

- A. Find all the eigenvalues of the matrix A.
- B. Find the LU decomposition of the matrix A, A = LU, where L is a lower triangular and U is an upper triangular matrix.
- C. For the system of equations.

x + y + z - 1

$$x + 2y + 4z = \alpha$$

 $x + 4y + 10z = \alpha^2$

Find the value of a for which the system has no solution, unique solution and infinite solutions.

2. Consider a two-dimensional vector field

 $F_1(x, y) = \langle -y, x \rangle$

And a three-dimensional vector field

 $F_2(x, y, z) = \langle xy, yz, xz \rangle$

- A. Find $div(F_1)$ and $div(F_2)$, where div denotes the divergence of a vector field.
- B. Find curl(F₂). Is F₂ a conservative vector field?
- C. Find a scalar function f(x, y, z) such that $grad(f) = F_2$, where grad denotes gradient.
- D. Verify Green's theorem for F_1 on the circle C centered at the origin of radius one.
- 3. Consider a binomial experiment of flipping a biased coin five times with probability of head, p = 0.75 and probability of tail, q = 0.25 in each flip.
 - A. What is the probability that last two flips will be heads if the first three flips are known to be talks?
 - B. Let X be the random variable which counts the number of heads in the experiment. What are all distinct values taken by X? Find P(X = a) for all values a taken by X.
 - C. Find the expected number of heads in the experiment by evaluating the expectation, E(X).
 - D. Find the uncertainty in the experiment by calculating the entropy, H(X).

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- 4. A. Using truth tables or otherwise, determine which of the following logical experession are equivalent to each other.
 - i. PV ~ Q
 ii. ~ (~ P ^ Q)
 iii. (P ^ Q) V (P^ ~Q) V (~ P^ ~Q)
 - B. Let $X = \{S_1, S_2, S_3, S_4, S_5\} Y = \{L_1, L_2, L_3\}$ be the sets of satellites and launching sites respectively. If each site launches at least one satellite, find the number of ways to launch satellites in the space.
 - C. Using the depth-first or breadth-first search algorithm, write an algorithm in words to find whether a graph, G, is connected.
 - D. Describe the greedy algorithm in words for colouring vertices of a graph. Let G be a graph on 5 vertices with degrees 1, 1, 2, 2 and 2. What is the minimum number of colour you need using greedy algorithm to color any such graph?
 - E. Find the generating function for the Fibonacci sequence.
- 5. A. Consider the following Gate circuit with inputs A, B and C



Write the Boolean expression for the above circuit.

Using Boolean algebra techniques, simplify the expression obtained in (i).

Draw a Gate circuit for the simplified expression obtained in (ii).

- B. Find 8-bits 2's complement representation of -127.
- C. Convert the IEEE-754 32-bit floating point number into decimal.

- 6. A. Use the edit distance algorithm to convert DRONE to DRDO. Show the procedure of the conversion.
 - B. Number of visits of n websites are recorded in an array A. Write an algorithm to find Kth least visited website. Using the above algorithm, solve for the following, K = 3 and $A = \{74, 106, 45, 39, 210, 157\}$.



- C. Message "DRDO DEFENCE DRONE" needs to be encoded into binary digits '0', '1' such that the size of encoded words in least. Use Huffman coding to encode the above message. Explain why Huffman coding works.
- D. Link state routing protocol uses Dijikstra algorithm for finding the shortest path. Use it to find the shortest path from vertex a to all other vertices in the network with vertex set, V = {a, b, c, d, e, f} and edge set, E = {(a, b, 3), (a, d, 1,), (a, c, 2), (b, d, 2), (f, d, 1), (b, e, 3), (d, e, 4), (f, e, 2), (c, f, 3)}.
- 7. A. Write recursive C functions to
 - i. Check whether a given binary tree is a Binary Search Tree (BST).

ii. Count the number of leaf nodes in a BST.

For the first case, the recursive function should return true or false depending on whether the given binary tree is a BST or not. In the second case, recursive function should return an integer value indicating the number of leaf nodes. Assume that appropriate data structures (for example, binary tree and BST) are available.

- B. Assume that there is one abstract base class and three concrete classes that inherit from the abstract base class. The abstract base class has one abstract method. Demonstrate the use of polymorphism, method overloading and overriding. You can assume any appropriate names for the classes and methods. Code can be written either in C++ or Java. Clearly indicate (or write) where you have used polymorphism, method overloading and overriding.
- C. Suppose we have has table with 2n slots with collisions resolved by changing and suppose that n keys are inserted into table.

Note: Assume simple uniform hashing i.e., each key is equally likely to be hashed into each slot.

What is the expected number of elements that hash into ith slot?

Suppose hash table size is 11. Open addressing and double hashing is used to resolve collision. Two hash functions are $H_1(k) = k \pmod{11}$ and $H_2(k) = 5 - (k \pmod{5})$. What values will be in the has table after inserting 16, 23, 9, 34, 12 and 56.

- 8. A. For a pipelined CPU with single ALU, consider the following situations:
 - i. The (j + 1)th instruction uses the result of the (j)th instruction as an operand.
 - ii. The execution of a conditional jump instruction.
 - iii. The (j)th and (j + 1)th instructions require the ALU at the same time.

Which of the above cases can cause a hazard and why?

- B. What is the least number of temporary variables required to create a three-address code in static assignment from for the following expression. Justify.
- C. The size of physical address space of a processor is 2^p bytes. The word length is 2^w bytes. The capacity of cache is 2ⁿ bytes. The size of each cache block is 2^M words. For a k-way set associative cache memory, find the length (in terms of the number of bits) of tag fields? Justify.