Class Test: Mathematics for Computing

Answer all the questions

Full Marks: 20 **Time: 45 minutes**

1. a. Prove that if $\{a_n^{(p)}\}$ is a particular solution of the nonhomogeneous linear recurrence relation with constant coefficients $a_n = c_1a_{n-1} + c_2a_{n-2} + \cdots + c_ka_{n-k} + F(n)$, then every solution is of the form $\{a_n^{(p)} + a_n^{(h)}\}$, where $\{a_n^{(h)}\}$ is a solution of the associated homogeneous recurrence relation $a_n = c_1a_{n-1} + c_2a_{n-2} + \cdots + c_ka_{n-k}$.

   c. What form does a particular solution of the linear nonhomogeneous recurrence relation $a_n = 6a_{n-1} - 9a_{n-2} + F(n)$ have for $F(n) = n3^n$, and $F(n) = n^2 2^n$?

6+4=10

2. a. Find all solutions of the recurrence relation $a_n = 3a_{n-1} + 2n$.

   b. Find the solution of the recurrence relation in Question 2a for initial condition $a_1 = 1$.

   c. Find the solution of the recurrence relation $a_n = 2a_{n-1} - a_{n-2} + 2^n + 2$, where $a_1 = 7$, and $a_2 = 19$.

4+2+4=10

M.Sc. Semester – I Examination, 2023

2023

Subject: Computer Science

Paper Code & Name: CSMC-102 (Data Structures and Algorithms)

Full Marks: 30

Date: 09.01.2024 **Time and Duration: 12.30 PM – 2:00 PM; 90 Minutes**

You are informed to note down the following instructions carefully:
Promise not to commit any academic dishonesty.
Candidates are required to answer in their own words as far as applicable.

1. Answer any five from the following: [2×5 = 10]

(a) Consider the following tree and show it in other forms of tree representation: (P(W(U,V), Q(T), O(S(Y), R(Z,N), X))).

(b) Why is it necessary to make a binary tree height balanced?

(c) What is DFS? Discuss its complexity issues.

(d) Show that the external path length of a 2-tree is minimum when all the leaves of the tree are on the same level or on two adjacent levels.

(e) Suppose that you are given three different weights X, Y, and Z. Draw a decision tree to compare the weights in ascending order.

(f) Prove that the binary search takes O(log n) time for an ordered list of n elements.

(g) Differentiate B*-tree from B-tree.

2. Answer any four from the following: [4×5 = 20]

(a) Obtain the addressing formula for the element A[i_1, i_2, …, i_n] in an array declared as A[l_1 .. u_1, l_2 .. u_2, …, l_n .. u_n]. Assume a row-major representation of the array with one word per element and α is the address of A[l_1, l_2, …, l_n]. Show that the addressing formula is linear.

(b) Write an algorithm for translating a given expression in infix form to its equivalent postfix form. Consider an example expression in infix form that comprises at least five different operands and at least five different operators, and show how the algorithm works for it. Then, how the given expression could be evaluated?

(c) Let T be a 2-tree with k leaves. Then prove that the height h of T satisfies $h \geq \lceil \lg k \rceil$ and the external path length E(T) satisfies E(T) $\geq k \lg k$.

(d) What do you mean by tree traversal? What are the different types of tree traversal? Assuming a pair of tree traversals is given, can we construct the tree uniquely? Either prove or disprove any one of your assumed statements.

(e) Clearly state, if there are any assumptions, and describe how BFS may work to find out one of the shortest paths between a pair of vertices of a graph, with the help of a suitable data structure.

(f) Consider the following sequence and insert the keys, in the order given, to build them into an AVL tree. Show the tree after each insertion. Then, delete l from the final AVL tree obtained.

$a,\ u,\ w,\ d,\ y,\ l,\ f,\ m,\ j,\ r$

MIDTERM

1st SEMESTER M.Sc.(COMPUTER SCIENCE) EXAMINATION,2023

PAPER NO. - CSMC103 (ADVANCED COMPUTER ARCHITECTURE)

Time: 45 Minutes

Answer any five questions: **[5x2=10]**

a. What is the significance of virtual memory in computer architecture? Briefly explain.

b. How will you justify the usage of cache memory? Express your claim in terms of the relevant parameter set.

c. Critically comment on the phrase - 'execution of instruction'.

d. Evaluate the maximum achievable speedup for a computing environment with a large number of processors and programs having 10% sequential part.

e. Comment on the desirable features of a processor, a member of any multi-processor system.

f. What are the different pipeline hazards? How do you avoid them?

Answer any five questions: **[5x4=20]**

a. Comment on the latest development of processors and associated technologies.

b. Briefly explain the alternative techniques to reduce cache misses.

c. Estimate the performance degradation factor in pipelined architecture for branch instructions regarding relevant parameters.

d. What are the reasons that justify the introduction of delay stages in nonlinear pipeline architecture that may reduce the synthesized minimal average latency? Justify your answer/

e. What is the cache coherence problem (CCP)? Discuss the alternative resolution techniques for CCP in brief.

f. Consider the following working environment to find the address bit pattern of cache memory using set associative and direct mapping:

Main Memory size = 256 KB
Cache size = 64 KB
Block size = 32 B
Set size = 4 Blocks

Internal Examination
M.Sc. (Computer Science), Semester – I
Paper Code – CSMC104
Paper Name – Object Oriented Analysis and Design
Total Marks- 30

1. Answer any five. $5 \times 2 = 10$

a) What is multiple inheritance?
b) What do you mean by covariant return type?
c) Explain the purpose of 'this' pointer.
d) Give a few examples of behavioural UML diagrams.
e) How to represent a time dependent event in an activity diagram?
f) Explain the use of Swimlane.
g) Explain the use of reflexive association w.r.t class diagram.

2. Answer any two. $2 \times 5 = 10$

d) What are the different type of constructors available in JAVA. Explain each of them with suitable example.
e) Explain the differences between method hiding and method overriding in JAVA.
f) Explain the use of Joins and Forks operations in an activity diagram using suitable examples.

Ten marks to evaluated based on assignments.

2023

COMPUTER SCIENCE

Paper : CSMC - 101

(Mathematics for Computing)

Full Marks : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

Answer ***question nos.*** **1** & **2** and ***any four*** questions from the rest.

1. Answer ***any five*** questions : 2×5

(a) How do you distinguish between a *trail* and a *path* for a graph?

(b) State the four-color theorem for a graph.

(c) Find all solutions of the recurrence relation $a_n = a_{n-1} + 2a_{n-2}$ with initial conditions $a_1 = 0$, $a_2 = 6$.

(d) You toss a fair coin three times, given that a head is observed at least once, what is the probability that you observe at least two heads?

(e) Define Span and Spanning Set in context of Vector space V.

(f) What can you say about two non-zero vectors u and v that satisfy the equation $\|u+v\| = \|u\| + \|v\|$?

(g) Show that the standard unit vectors form a basis for $V = R^3$.

(h) Suppose the characteristic polynomial of a matrix A is found to be $P(\lambda) = (\lambda - 1)(\lambda - 3)^2(\lambda - 4)^3$. How many eigen values does A have? Is A invertible?

2. Answer ***any five*** questions : 4×5

(a) "$K_{3,3}$ is a planar graph."— Comment on the correctness of the statement and justify your opinion.

(b) "The degree of the unbounded region for a simple graph is at least 3."— Comment on the correctness of the statement and justify your opinion.

(c) "A 6-vertex graph cannot be self-complementary."— Comment on the correctness of the statement and justify your opinion.

(d) Consider the following function :

$$p_x(x) = \begin{cases} \frac{1}{10}x & \text{if } x \in \{1,2,3,4\} \\ 0 & \text{otherwise.} \end{cases}$$

Determine whether the above function is a valid probability mass function. Define and give an example of an Estimator.

(e) Show that the three vectors $u = \{0,3,1,-1\}$, $v = \{6,0,5,1\}$ and $w = \{4,-7,1,3\}$ form a linearly dep set in R^4. Also, express each vector as a linear combination of other two.

(f) Show that the following matrix is not diagonizable.

$$A = \begin{bmatrix} 1 & 0 & 0 \\ 1 & 2 & 0 \\ 3 & 5 & 2 \end{bmatrix}$$

(g) Show that v is a subspace of the vector space of 2×2 real matrix with usual matrix addition scalar multiplication.

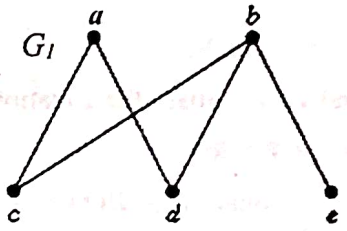
$$V = \left\{ \begin{bmatrix} a & b \\ c & d \end{bmatrix} : a + d = 0, a, b, c, d \in R \right\}.$$

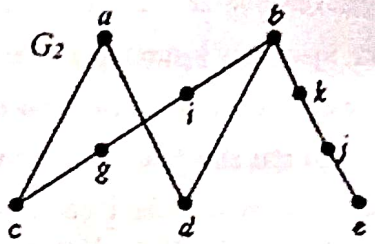
3. (a) State Euler's formula to find the number of regions for a planar graph.

(b) Does Euler's formula stated above remain valid even if the graph is not planar? Justify your opinion.

(c) State the first theorem of Kuratowski.

(d) Determine the sequence of elementary subdivisions needed to obtain G_2 from G_1. Illustrate intermediate states clearly. 1+(1+2)+2





4. (a) What would be the Chromatic number of a Cycle G with an odd number of nodes? Why?

(b) Distinguish between the maximal and maximum matching for a graph. Draw an example indicate a maximum matching for a graph G having at least five edges.

(c) Schedule the final exams for Course-115, Course-116, Course-185, Course-195, Course-1 Course-102, Course-273 and Course-473, using the fewest number of different time slots, if students are taking both Course-115 and Course-473, both Course-116 and Course-473, b Course-195 and Course-101, both Course-195 and Course-102, both Course-115 and Course-1 both Course-115 and course-185, and both Course-185 and Course-195, but there are students every other pair of courses. 3+3

5. (a) What is a Particular Solution for a non-homogeneous recurrence relation?

(b) Prove that if $\{a_n^{(p)}\}$ is a particular solution of the non-homogeneous linear recurrence relation w constant coefficients

$$a_n = c_1 a_{n-1} + c_2 a_{n-2} + \ldots + c_k a_{n-k} + F(n),$$

then every solution is of the form $\{a_n^{(p)} + a_n^{(h)}\}$, where $\{a_n^{(h)}\}$ is a solution of the associated homogeneous recurrence relation $a_n = c_1 a_{n-1} + c_2 a_{n-2} + \ldots + c_k a_{n-k}$.

(c) What form does a particular solution of the linear non-homogeneous recurrence relation $a_n = 6a_{n-1} - 9a_{n-2} + F(n)$ have for $F(n) = n^2 2^n$ and for $F(n) = n3^n$? 1+4+(3+2)

6. (a) Determine the values of K so that the following system of equations has (i) no solution, (ii) more than one solution and (iii) a unique solution.

$$x + y - z = 1$$
$$2x + 3y + Kz = 3$$
$$x + Ky + 3z = 2.$$

(b) Find bases for the eigenspaces of

$$A = \begin{bmatrix} 0 & 0 & -2 \\ 1 & 2 & 1 \\ 1 & 0 & 3 \end{bmatrix}$$ 6+4

7. (a) Show that the set $\{(2, -3, 1), (4, 1, -5), (1, 1, 1)\}$ is a set of mutually orthogonal vectors in the inner product space R^3 with standard inner product. Is this set of vectors a basis of R^3? Justify.

(b) Prove that the set $S = \{(1,1,0), (1,0,1), (0,1,1)\}$ is a basis of vector space R^3. Show that the vector $(1,0,1)$ of the set S may be replaced by $(1,1,1)$ to form a new basis for R^3. However, the same is not true for vector $(3,1,2)$. 5+5

8. (a) Let u and v are two vectors within an inner product space V such that $\langle \vec{u}, \vec{v} \rangle = \| \vec{u} \| \cdot \| \vec{v} \|$. Prove that u and v must be linearly independent.

(b) What is the maximum possible rank of an $m \times n$ matrix A that is not square?

(c) Find the rank and nullity of the matrix

$$A = \begin{bmatrix} -1 & 2 & 0 & 4 & 5 & -3 \\ 3 & -7 & 2 & 0 & 1 & 4 \\ 2 & -5 & 2 & 4 & 6 & 1 \\ 4 & -9 & 2 & -4 & -4 & 7 \end{bmatrix}.$$ 4+1+5

2023

COMPUTER SCIENCE

Paper : CSMC-102

(Data Structures and Algorithms)

Full Marks : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

Answer ***Question No.* 1**, ***Question No.* 2**, and ***any four*** from the rest.

1. Answer ***any five*** questions : 2×5

   (a) Differentiate little-oh from Big-Oh.

   (b) State two similarities and two differences between BFS and DFS.

   (c) How can a three-dimensional sparse matrix be defined? Give reasons to support your answer.

   (d) Define the vertex cover problem of a graph and explain it with the help of a suitable example.

   (e) Highlight two strengths and two weaknesses of *GraphSort*.

   (f) Consider a graph $G = (V, E)$, where $|V|$ is at least 6 and $|E|$ is at least 7, and show how disjoint set data structure may work on it in identifying pendant and isolated vertices.

   (g) State *travelling salesman problem* in its decision version and optimization version.

2. Answer ***any five*** questions :

   (a) Define tree. What do you mean by tree structure? Provide different ways of viewing the following tree: (A(B(E, F), C(G), D(H(K), I(L, M), J))). 1+1+2

   (b) Define a graph theoretic problem whose implementation could be performed with the help of *queue* as a data structure. Clearly explain the steps of an underlying algorithm and show how queue may play its role to solve the problem. 1+3

   (c) State the purpose of *Karatsuba algorithm*. Use this algorithm to compute the value of (1234 × 4321), and also mention its complexity issues. 1+(2+1)

   (d) Define and exemplify binomial heap. Prove that there is at most one binomial tree in a binomial heap whose root has a given degree. 1+3

   (e) State the associated problem and satisfy the following query with necessary proof: "Given an undirected graph G, can G be painted with three colours?" 4

   (f) What do you mean by *heuristic*? When do we usually devise a heuristic algorithm? How is it different from approximation algorithm? 1+1+2

(g) Highlight the important things that helped to develop the foundations for the NP-completeness following the published article entitled "The complexity of theore procedure" authored by Stephen Cook.

3. (a) Given two strings S_1 = "BDCABA" and S_2 = "ABCBDAB", devise an algorithm tabulation to find the longest common subsequence between the two strings. Also, cal time and space complexities of the devised algorithm.

(b) Define a *matroid* and state its structural properties.

(c) If a graph can be modelled as a matroid, then prove that the proposed structure satisf structural properties of a classical matroid.

4. (a) What do you mean by a *height-balanced tree*? State reasons to realize such trees in

(b) Consider the following sequence of elements and insert them, in the order given, to build balanced tree after each insertion. Then, delete n from the final height-balanced tree

$$b,\ v,\ w,\ f,\ z,\ n,\ h,\ p,\ k,\ s$$

(c) Compute the smallest number of keys that when inserted in an appropriate order, wi B-tree of order m to have three levels (assuming the root is at level one). (1+1)

5. (a) Suppose that L_1 and L_2 are two lists containing n_1 and n_2 integers, respectively, and bot already sorted in their numerical values in non-descending order,

(i) Use the idea of binary search to describe how to find the median of the $n_1 + n_2$ i total without combining the lists.

(ii) How the same search technique could help in computing the median of the combi

(b) Devise a simple, easy-to-calculate hash function for mapping three-letter words to integer 0 and n-1, both inclusive. Find the values of your function on the words: LPA, MAP, E TET, SAT, CTS, LAP, PAM, SIT, PUB, JEE, BTA and TCS for $n = 7$. Try for as few as possible.

6. (a) Define a biconnected graph and a biconnected component (BCC) of a graph. Devise an to compute the BCCs of graph $G = (V, E)$, where $V = \{a, b, c, d, e, f, g\}$ and $E = \{b, c\}, \{a, c\}, \{c, d\}, \{b, e\}, \{b, f\}, \{e, f\}, \{f, g\}\}$. Also, mention the data structur to utilize and state the time complexity of the algorithm.

(b) Briefly state the underlying principle of *ShellSort*, and using this principle, sort the numbers with diminishing increments 5, 3, and 1.

104, 27, 32, 96, 109, 63, 41, 10, 59, 18, 53, 60, 91, 46 (1+3

7. (a) State the steps of proving a new problem NP-complete, and briefly explain with the l appropriate example.

(b) How are the problems in NP and the problems in NP-hard differentiated? How are the

(c) Relatively compare the proofs of NP-completeness by *restriction* and *local replace* explain with necessary examples.

8. (a) Critically comment on the following statement and justify the same with the help of proper example(s)— "The underlying principle of *SieveSort* is nothing but a *multi-way Quick Sort* algorithm." Also, give an example to show that *SieveSort* is not a stable sorting algorithm.

(b) What do you mean by *amortized analysis* of algorithms? How is it differentiated from worst-case analysis and average-case analysis? State the role of *credit balance function* in computing the amortized cost of some algorithm. (3+2)+(1+2+2)

2023

COMPUTER SCIENCE

Paper : CSMC-103

(Advanced Computer Architecture)

Full Marks : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

Answer ***question nos.*** **1, 2,** and ***any four*** from the rest.

Answer ***any five*** questions : 2×5

(a) What is ISA? What are the problem areas that cause a poorly designed instruction set to stall frequently in the pipelined processor?

(b) What is clock skewing? What are the different techniques to resolve clock skewing?

(c) What are the desirable properties of RISC architecture?

(d) What are the desirable properties of a processor to be a member of a multiprocessor system?

(e) What is virtual memory? How a virtual address is mapped into a real address?

(f) Discuss the alternative flow control strategies in any message-passing system.

(g) How many states are there in 4×4 switch including broadcasting and permutation? Comment on the control line format.

Answer ***any five*** questions : 4×5

(a) What are the different pipeline hazards? How do you avoid them?

(b) Let A be a $2^k \times 2^k$ matrix stored in row-major order in the main memory. Prove that the transposed matrix A^T can be obtained by performing k-perfect shuffles on A.

(c) Construct an example showing that the loss of a message can cause a deadlock among a set of communication processes.

(d) For a given latency cycle, split out the design steps to get a reservation table. Explain with an example of a latency cycle (2,3,2,5).

(e) Comment on the impact of branch instructions in pipelined architecture with an appropriate set of parameters and an example.

(f) What is memory interleaving? Briefly explain two interleaved memory organizations with suitable assumptions.

(g) A computer has a 16-way interleaved memory. We are required to access a 64 × 64 matrix. Compute the total time required for the access, if the elements are accessed by

(i) row-by-row

(ii) column-by-column.

S(1st Sm.)-Computer Science-CSMC-103

3. (a) Given that 'c' is the number of 0s in the initial collision vector, show that for any static pipe and any modified state diagram, the total number of states is no greater than 2^c. Can you a similar statement for a dynamic pipeline? Justify.

(b) Considering the following reservation table list all latencies and corresponding cross-coll matrices. Find the MAL for job type A only.

S 1	A	B		A	B
S 2		A		B	
S 3	B		AB		A

4. (a) Write an algorithm to test whether two input-output pairs of desired connections in an SE-M (8×8) will lead to conflicts or not.

(b) Critically comment on XOR and destination tag routing schemes for MICN.

(c) Critically comment on blocking inter-connection networks in terms of permutation mapping.

5. (a) Comment on the characteristic features of any systolic array or processors.

(b) What is meant by systolization?

(c) Identify all possible hazards for the following code segment with a three-stage pipeline architec

$R \leftarrow R + 1$

$ACC \leftarrow ACC + R$

$Rl \leftarrow ACC$

$ACC \leftarrow ACC + R$

$M \leftarrow ACC$

6. (a) Construct an example showing that the loss of a message can cause a deadlock among a se communication processes.

(b) Explain the following terms associated with a message-passing mechanism in the multi-comp network :

(i) Store-and-forward routing at the packet level and wormhole routing at the flit level.

(ii) Buffering flow control using virtual cut-through routing.

(c) What is the difference between interrupts, function calls and message passing to transfer execution flow controls?

7. (a) Critically comment on Data Flow Architecture in contrast to Control Flow Architecture. What are the alternatives to DFA? Compare and contrast them.

(b) Write an algorithm to multiply two matrices A_{nxn} and B_{nx1}. Modify the algorithm to incorporate the spatial locality and temporal locality so that the algorithm can be mapped to a suitable array of processors for systolic architecture. Make suitable assumptions.

(c) What are cache coherence resolution techniques? 4+4+2

2023

COMPUTER SCIENCE

Paper : CSMC-104

(Object Oriented Analysis and Design)

Full Marks : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

Answer ***question nos.*** **1 & 2** and ***any four*** **from the rest.**

1. Answer ***any five*** from the following : 2×5

   (a) What do you mean by Covariant Return Type?

   (b) What is Hybrid Inheritance?

   (c) What is the difference between Error and Exception?

   (d) What do you mean by Finalization in JAVA?

   (e) How to represent a Time Dependent Event through an Activity diagram?

   (f) Explain a Reflexive Association w.r.t. Class diagram.

   (g) What is the difference between Early Instantiation and Lazy Instantiation in Singleton design pattern?

2. Answer ***any five*** from the following : 4×5

   (a) Explain the difference between Method Hiding and Method Overriding in JAVA.

   (b) Why high Cohesion and loose Coupling is desirable for a system?

   (c) Explain how JAVA allows Dynamic Method Dispatch.

   (d) Why the Factory Method design pattern is also called as Virtual Constructor? Explain with example.

   (e) Point out the relative advantages and disadvantages of Class diagram and Object diagram.

   (f) With a suitable example explain how Join and Merge operations are used in an Activity diagram.

   (g) What do you mean by Sequence Diagram Fragments? Write down the usage of Optional, Alternative and Parallel Fragments.

3. (a) Justify the statement — "JAVA is platform independent and secure."

   (b) What are the different type of Constructors available in JAVA? Explain each of them with suitable examples.

   (c) How a Class in Java can be prevented from getting Inherited? Illustrate with an example.

   2+5+3

4. (a) Explain the difference between Static and Dynamic Polymorphism.

(b) With an example JAVA program explain how Multiple Inheritance is achieved using Inter

5. Consider a RFID based Hospital Management System where the patient, employees, visitors are we a RFID tag and several RFID readers has been deployed in the hospital premises to sense and their movements / activities. Next, the RFID readers send those sensed data to the Central Serve final processing and storage.

(a) Draw a Sequence diagram to show how the data communication takes place within the syst

(b) Also draw a State Machine diagram to show the flow of events within the system. If yo considering any specific assumptions then mention them clearly.

6. (a) Explain how Builder design pattern constructs a complex object from simple objects u step-by-step approach.

(b) Justify how Adapter design pattern allows incompatible interfaces between classes to work toge

7. (a) What are the different relationships between the Actors and Usecases in an Usecase diagra Explain each of them.

(b) Consider an Online Shopping System containing Customers and Admin. Customers are allowe check-in, browse Products, Add products to cart, check-out and the Admin is enabled to mana and change the Inventory. Draw an Usecase diagram to show different operations of the syst If you are considering any specific assumptions then mention them clearly.

8. Write short notes on (***any four***) :

(a) Function overloading in JAVA

(b) Reflexive Association

(c) Use of Guard Conditions in Sequence diagram

(d) Difference between Abstract Factory and Concrete Factory

(e) Prototype Registry

(f) Command design pattern.
