Roll No.:.....

National Institute of Technology, Delhi
Name of the Examination: End Semester (Theory)
Spring Examination (2023)

Branch: Computer Science and Engineering
Semester: B Tech (Ist year IInd Sem)
Title of the Course: Data Structure **Course Code: CSBB 151**
Time: 3 Hours **Maximum Marks: 50**

Q. No.	1	2	3	4	5
Marks	12	10	8	10	10
CO	1	2	4	3	2

Note: All questions are compulsory.

Q1. Solve the following questions: **<Marks 4+4+4=12>** **<CO1>**

A. $f_1(n) = 2^n, f_2(n) = n^{\{\frac{3}{2}\}}, f_3(n) = nlog_2 n, \quad f_4(n) = n^{\{\log_2 n\}}$. Compare them and arrange in descending order as per their rate of growth.

B. $f(n) = \begin{cases} n^3 & 0 < n < 10000, \\ n^2 & n \geq 10000 \end{cases}$ and

$g(n) = \begin{cases} n & 0 < n < 100, \\ n^3 & n > 100 \end{cases}$ Solve them and determine whether $f(n) = O(g(n))$ or $g(n) = O(f(n))$.

C. Write the recurrence equation $T(n)$ for time complexity of following algorithm. Then, solve the recurrence equation and evaluate the time complexity.

Algorithm (n, k)

```
{
  If (n < 1)
    {
      Print("Error");
    }
   Else
    {
      For (i=1; i<=k, i++)
          {
           A[n]=i;
           Algorithm(n-1, k);
           }
       }
}
```

Q2. Solve the following questions: **<Marks 2+2+4+2=10> <CO2>**

A. Find the max heap size for the following elements: 89,19,40,17,12,10,2,5,7,11,6,9,70

B. What is the time complexity for finding a maximum element and minimum element in max heap data structure.

C. Convert the following infix expression into prefix and postfix using stack. Then, evaluate the converted expression using stack for the following expression.
K+L-M*N+O^P^Q*W/U/V*T+Q

D. Define the double ended queue and priority queue.

Q3. Solve the following questions using partition algorithm used in quick sort. **<Marks 4+4=8> <CO4>**

A. Assume that the partition algorithm partitions the input array of size n into 1:9 ratios constantly. The, determine the total number of levels in the corresponding tree when the size of every sub array is 1.

Hint: In 1^{st} pass: partition algorithm partitions the input array of size n into $\frac{n}{10}$ and $\frac{9n}{10}$ sizes of two sub array.

In 2^{nd} pass: partitions the list of size $\frac{n}{10}$ into $\frac{n}{100}$ and $\frac{9n}{100}$, and the list of size $\frac{9n}{10}$ will be partitioned into $\frac{9n}{100}$ and $\frac{81n}{100}$. This process is going on upto the size of every sub array will not be 1.

B. As it is known that time complexity for build-heap is $O(n)$ by evaluating the expression $T(n) = \sum_{h=0}^{logn} O(h) \frac{n}{2^{\{h+1\}}}$ (implies that you have to apply heapify procedure for $\frac{n}{2^{\{h+1\}}}$ number of nodes at height h). The complexity for one heapify procedure at height h is $O(h)$, and the height varies from 0 to $\log_2 n$ in a tree with n nodes. However, if you think that there are n nodes in a tree and if the heapify is applied at every node, then the complexity becomes $O(n \log_2 n)$ with the complexity for one heapify is $\log_2 n$. Justify, why the time complexity for build-heap is $O(n)$ is correct.

Q4. Solve the following questions: **<Marks 6 + 4=10> <CO3>**

A. Suppose you have given an array with the following elements:
10, 25, 0, 5, 12, 24, 28, 11.
Then construct the Binary search tree and write the in-order, pre-order, post order traversal for the constructed Binary

search tree.

B. Insert the element 13 in the above constructed Binary Search tree. Further, determine the time complexity for this insertion operation. Next, delete the element 12 from this Binary Search Tree, and determine time complexity for this deletion operation.

Q5. Solve the following questions. **<Marks 4 + 3+3= 10 >** **<CO2>**

A. Compute the total time complexity for merging the given number of "$log_2 n$" sorted lists using **two way merge procedure** (**at a time only two lists will be merged simultaneously**) where the size of each list is $\frac{n}{\log_2 n}$ (Explain with tree structure).

B. Write the algorithm for topological sort and evaluate the time complexity.

C. Suppose relation R is defined over a set $S = \{1, 2, 3, 4, 5, 6\}$ such that $R = \{(1,2), (1,3), (2,4), (3,5), (4,5), (4,6)\}$. Provide, the possible output of a schedule for completing the tasks for a set S using the topological sort.

Course Matrix (CO-PO-PSO Mapping)

COs	POs													
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	3	--	--	--	-	--	--	--	--	--	--	3	--
CO2	3	3	2	--	--	--	--	--	--	--	--	--	3	--
CO3	1	3	2	-	2	1	-	-	1	-	1	1	3	1
CO4	2	2	1	1	-	2	3	-	3	1	2	2	2	2

1=Addressed to small extent
2= Addressed significantly
3= Addressed strongly (major part of course)

Roll No.:.....

National Institute of Technology, Delhi
Name of the Examination: End Semester (Theory)
Spring Examination (2023)

Branch: Computer Science and Engineering
Semester: B Tech (1st year IInd Sem)
Title of the Course: Discrete Structure **Course Code: CSLB 152**
Time: 3 Hours **Maximum Marks: 50**

Q. No.	1	2	3	4	5	6
Marks	6	5	9	12	8	10
CO	2	2	2	1	3	4
PO	1	1	2	3	3	3

Note: All questions are compulsory.

Q1. Solve the following questions. **<Marks 3 + 3=6>** **<CO2>**

A. Write the contrapositive, converse, and inverse for the following propositional statement.
"A prime integer is prime only if it has no divisor other than 1 and itself."

B. Write the argument form with conclusion for modes tollen, and modus ponen. Then derive the modus tollen in the form of modus tollen to show the validity of argument form of modus tollen.

Q2. Identify whether the written expression in predicate form is correct or not for English text statement. **<Marks 5>** **<CO2>**

Every student in CSLB 152 has studied mathematics for continuous domain.	$\forall x: [S(x) \wedge C(x)]$
Some of the students in CSLB 152 has studied mathematics for continuous domain.	$\exists\, x: [S(x) \rightarrow C(x)]$
Equal set A and B	$\forall x: (x \in A \leftrightarrow x \in B)$
$A \subseteq B$	$\forall x: (x \in A \rightarrow x \in B)$
$A \subset B$	$\forall x: (x \in A \rightarrow x \in B) \wedge$ $\exists y: (y \notin A \wedge y \in B)$

Q3. Prove that the following statements: **<Marks 3+3+3=9>** **<CO2>**

A. If $n^3 + 5$ is even then n is odd.

B. There exists irrational numbers x and y such that x^y is rational number.

C. Establish the equivalence between regular form of induction and strong induction.

Q4. Prove that the following statements: **<Marks 3+3+6=12> <CO1**

A. Let A, B, C be arbitrary sets, such that $\forall x: (x \in A \rightarrow (x \in B \rightarrow x \in C))$is true. Is $A \cap B \subseteq C$?

B. How many relations are there on a set $S = \{1, \dots, n\}$ which are reflexive and symmetric both together?

C. Let R be an equivalence relation and aRb , then prove that the equivalence classes $[a], [b]$ has the relation either $[a] = [b]$ or $[a] \cap [b] \neq \phi$.

Q5. Prove the following theorems. **<Marks 4 + 4 = 8 > <CO3>**

A. Theorem 1: If sets A *and* B are countable sets such that $A \cap B \neq \emptyset$ and $A \neq B$. Then $A \cup B$ is also countable set.

B. Theorem 2: For every set A, prove that $|A| < |P(A)|$, where $P(A)$ is the power set of A.

Q6. Prove the following questions. **<Marks 4 + 4 +2= 1(<CO4>**

A. Let (G, o) be a finite group and $H \subseteq G, H \neq \phi$. Let $x \epsilon G$ and $H = \{x^0, x^1, \dots, x^{m-1}\}$. Then characterization $\forall x, y : x, y \in H \rightarrow xoy \in H$ is sufficient to declare H is a subgroup of G.

B. Let (G, o) be a finite group and $H \subseteq G, H \neq \phi$, and $g_1, g_2 \in G$. Then prove that either $g_1 o\, H = g_2 o\, H$ or $g_1 o\, H \cap g_2 H$.

C. Give the proper logical argument for a finite group (G, o) of prime order p, where $\forall\, x: x \in G$ such that $x \neq 1$ is a generator for the group G.

Course Matrix (CO-PO-PSO Mapping)

COs	POs													
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	1	1	3	-	-	2	-	1	1	2	2	1	2
CO2	3	3	2	3	-	3	1	1	2	3	3	3	3	3
CO3	1	3	2	-	2	1	-	-	1	-	1	1	3	1
CO4	2	2	1	1	-	2	3	-	3	1	2	2	2	2

1=Addressed to small extent

2= Addressed significantly

3= Addressed strongly (major part of course)

Roll No.:.....

National Institute of Technology, Delhi
Name of the Examination: End Semester (Theory)
Spring Examination (2023)

Branch: Computer Science and Engineering
Semester: B Tech (Ist year IInd Sem)
Title of the Course: System Programming **Course Code: CSLB 153**
Time: 3 Hours **Maximum Marks: 50**

Q. No.	1	2	3	4	5	6
Marks	6	5	9	12	8	10
CO	1	2	2	1	3	4
PO	1	1	2	3	3	3

Note: All questions are compulsory.

Q1. A. State the steps followed to design an assembler. **<Marks 3 + 2 +1=6>**
B. If Context-free grammars can represent every regular expression, State the need of Regular Expressions at all? **<CO1>**
C. Define Parse Trees. Where are they implemented in compiler?

Q2. Consider the following program segments **<Marks 5> <CO2>**

1. PG 1 START
   ENTRY SYM 11
   EXTRN PG 2, SYM 23
   DC A(PGA), A(PGB + 4)
   SYM 11 DC A(SYM 11-PG 1), (SYM 23 -PG 2)
   END

2. PG 2 START
   ENTRY SYM 23
   EXTRN PG 1, SYM 11

   SYM 21 DC A(SYM 11-2),A(SYM 21)
   SYM 22 DC A(PG 2+4),A(SYM 21 -PG 2)
   SYM 23 DC A(SYM 21 -PG 1)
   END

Assume these two programs (1 and 2) are to be loaded starting at location 200 in order PG 1 and PG 2. Fill the GEST for each symbol. Also give the ESD and RLD card entries for the above program segments.

Q3. A. Consider the following statements: **<Marks 2+2+2+3=9> <CO2>**
In Program A, a call to subroutine B is made. The subroutine B is not written in the program segment of A, rather B is defined in some another program segment C"
- Discuss if there is any problem in the scenario.
- If yes, how to overcome the problem and if no then discuss the reason.
- Illustrate the use of subroutine linkages in this entire process.

B. Evaluate how the elimination of sub expression is performed and in which phase?

Q4. A. Construct the parse tree/Decision tree for the following arithmetic expression: **<Marks**

COST=RATE*(START-FINISH)+2*RATE*(START-FINISH-100); **2+2+4+4=12>**

B. State the reason to divide the analysis phase of the compiler into lexical syntactic and semantic. **<CO1>**

C. Discuss the I/O buffering in the lexical analyzer.

D. List independent and dependent features in the assemblers and explain the program relocation.

Q5. The Tapid Terminal Sytsem has just contracted to design a one pass assembler to be part of the terminal service which will be implemented on IBM 360. The specification for assembler are needed so examine which of the following specifications will be implemented, will not be implemented or list restrictions in which it will work **<1 Mark each = 8 > <CO3>**

A. USING, DROP
B. START
C. EQU
D. DC,DS
E. Normal symbolic operation codes
F. EXTTRN
G. Labels on instructions
H. The instruction "B LABEL" where label is defined in the program.

Q6. A. Design the state transition diagram for the process in different states consider all possible transitions. Justify each transition with a reason. **<Marks 3 + 3+2 +2= 10 > <CO4>**

B. Argue with valid reasons why processors be assigned arbitrarily to a process in a multiprocessor system rather than requiring a one-to-one correspondence between processor and process?

C. Evaluate the following databases of compiler and assembler as pure or not and support with valid reasons:

- Symbol Table
- Macro table
- Opcode Table
- Code

D. Support the part of segmentation in dynamic storage allocation?

Course Matrix (CO-PO-PSO Mapping)

COs	POs													
	PO 1	PO 2	PO3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	1	1	3	-	-	2	-	1	1	2	2	1	2
CO2	3	3	2	3	-	3	1	1	2	3	3	3	3	3
CO3	1	3	2	-	2	1	-	-	1	-	1	1	3	1
CO4	2	2	1	1	-	2	3	-	3	1	2	2	2	2

1=Addressed to small extent
2= Addressed significantly
3= Addressed strongly (major part of course)

Roll No.:.....

National Institute of Technology, Delhi

Name of the Examination: B.Tech

End Semester Examination (Spring, 2023)

Branch : **CSE** **Semester** : **II**

Title of the Course : **Applied Linear Algebra** **Course Code** : **MALB152**

Time: 180 Minutes **Maximum Marks** : **50**

COURSE OUTCOMES		COGNITIVE LEVELS
CO1	To understand the concept of matrix and will be able to apply this to find the inverse of the matrix and to solve the system of equations.	**Understanding** (Level II)
CO2	Gain a understanding of the concept of vector space, Linear transformation and will be able to apply this in solving various linear models	**Applying** (Level III)
CO3	To learn concept of eigen values and eigen vectors and use it to diagonalize the matrix.	**Applying** (Level III)
CO4	Gain a understanding of concept of Inner product space and its various applications.	**Evaluating** (Level V)

Course Outcomes (CO's)	CO1	CO2	CO3	CO4
Questions No.	2,6,7,8	3,4,10,11	13,14	1,5,9, 12

Answer the following questions.
Note: All sections are compulsory.

Section A

Section A contains 04 questions (Question Number 1 to 4) of 01 Mark each.

Q1. Classify the quadratic form $Q(x) = 3x_1^2 + 2x_2^2 + x_3^2 + 4x_1x_2 + 4x_2x_3$ having eigen values 5,2 and -1.

Q2. Find the volume of the parallelepiped with one vertex at origin and adjacent vertices at (1,4,0), (-2,-5,2) and (-1,2,-1).

Q3. If A is any $n \times n$ invertible matrix. Then what will be the dimension of null space of A.

Q4. If A is any $n \times n$ non-singular matrix. Then what will be the rank of A.

Section B.

Section B Contains 07 theoretical questions (Question no. 5-11) of 04 Marks each.

Q5. Find (a) the maximum value of $Q(x) = 9x_1^2 + 4x_2^2 + 3x_3^2$ subject to the constraints $x^T x = 1$ *and* $x^T u_1 = 0$, where $u_1 = (1, 0, 0)$, (b) a unit vector where this maximum is attained.

Q6. Find two non singular matrices P and Q such that PAQ =I where $A = \begin{bmatrix} 0 & 1 & 2 \\ 1 & 2 & 3 \\ 3 & 1 & 1 \end{bmatrix}$. Also using that find A^{-1}.

Q7. State Cayley Hamilton theorem and verify Cayley Hamilton theorem for the matrix

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

Q8. Let $A = \begin{bmatrix} 1 & 3 & 4 \\ -4 & 2 & -6 \\ -3 & -2 & -7 \end{bmatrix}$ *and* $b = \begin{bmatrix} b_1 \\ b_2 \\ b_3 \end{bmatrix}$. Is the equation $Ax = b$ consistent for all possible b_1, b_2, b_3?

Q9. Find a least square solution of the inconsistent system $Ax = b$ for

$A = \begin{bmatrix} 4 & 0 \\ 0 & 2 \\ 1 & 1 \end{bmatrix}$, b=$\begin{bmatrix} 2 \\ 0 \\ 11 \end{bmatrix}$

Q10. Determine if $\{v_1, v_2, v_3\}$ is a basis for R^3, where $v_1 = \begin{bmatrix} 3 \\ 0 \\ -6 \end{bmatrix}, v_2 = \begin{bmatrix} -4 \\ 1 \\ 7 \end{bmatrix}, v_3 = \begin{bmatrix} -2 \\ 1 \\ 5 \end{bmatrix}$.

Q11. Let $T(x_1, x_2) = (3x_1 + x_2, 5x_1 + 7x_2, x_1 + 3x_2)$. Write the Matrix representation of T with respect to standard basis. Is this Linear transformation one-one, on to or both?

Section C

Section C contains 03 theoretical question (Question No. 12-14) of 06 Marks.

Q12. Change the quadratic form $3x_1^2 - 4x_1x_2 + 6x_2^2$ in to one with no cross product term.

Q13. Let $A = \begin{bmatrix} 6 & -2 & 2 \\ -2 & 3 & -1 \\ 2 & -1 & 3 \end{bmatrix}$. Find all the eigen values of A and a basis for corresponding eigen spaces. Also diagonalize the matrix A.

Q14. Find the orthogonal basis for the column space of the matrix $\begin{bmatrix} 3 & -5 & 1 \\ 1 & 1 & 1 \\ -1 & 5 & -2 \\ 3 & -7 & 8 \end{bmatrix}$