A. Course Handout (Version 1.0)

Institute/School Name	Chitkara University Institute of Engineering and Technology		
Department Name	Department of Computer Science & Engineering		
Programme Name	Bachelor of Engineering (B.E.), Computer Science & Engineering		
Course Name	Data Structures	Session	2024-2025
Course Code	23CS004	Semester/Batch	4th/2023
L-T-P (Per Week)	2-0-4	Course Credits	04
Pre-requisite	Basic concepts of computer fundamentals	NHEQF Level	05
Course Coordinator	Dr. Heena Wadhwa	SDG Number	4,8,9

CLO01	Understand the basics of data structure, complexity of algorithms, and the implementation of various operations on arrays and linked lists.
CLO02	Illustrate the concepts of stack and queue with their applications and apply recursion to solve certain problems.
CLO03	Persuade different searching and sorting mechanisms with their comparisons.
CLO04	Understand, implement, and analyze linked list and queue data structure and apply it to real-world problems.
CLO05	Analyze different tree traversal techniques and understand various kinds of trees.

1. Objectives of the Course

Data structures play a central role in modern computer science. Data structures are essential building blocks in obtaining efficient algorithms. This course covers elementary data structures (Array, Binary search trees) and algorithmic approaches to solve classical problems (sorting, graph searching). It Introduces the mathematical modeling of computational problems, as well as common algorithms, algorithmic paradigms, and data structures used to solve these problems.

The main objectives of the course are:

- To use object oriented programming knowledge for solving real world problem statements.
- To evaluate time-space complexity tradeoffs for all categories of algorithms.
- To understand concepts of searching and sorting techniques.
- To understand basic concepts of stacks, queues, list, and trees.
- To understand about writing algorithms and step by step approach in solving problems with the help of fundamental data structures.

2. Course Learning Outcomes

After completion of the course, student should be able to:

	Course Learning Outcome	*POs	**CL	***KC	Sessions
CLO01	Understand the basics of data structure, complexity of algorithms, and the implementation of various operations on arrays and linked lists.	PO1, PO2, PO3, PO4, PO9, PO11, PO12	K2	Factual Conceptual	**28**

CLO02	Illustrate the concepts of stack and queue with their applications and apply recursion to solve certain problems.	PO1, PO2, PO3, PO4, PO9, PO11, PO12	K3	Conceptual Procedural	**33**
CLO03	Persuade different searching and sorting mechanisms with their comparisons.	PO1, PO2, PO3, PO4, PO9, PO11, PO12	K3	Conceptual Procedural	**41**
CLO04	Understand, implement, and analyze linked list and queue data structure and apply it to real-world problems.	PO1, PO2, PO3, PO4, PO9, PO11, PO12	K4	Conceptual	**28**
CLO05	Analyze different tree traversal techniques and understand various kinds of trees.	PO1, PO2, PO3, PO4, PO9, PO11, PO12	K3	Conceptual	**20**
Total Contact Hours					**150**

Revised Bloom's Taxonomy Terminology

* PO's available at (shorturl.at/cryzF)

**Cognitive Level =CL

***Knowledge Categories = KC

Course Learning Outcomes	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CLO01	H	H	H	M					L		L	H
CLO02	H	H	H	M					L		L	H
CLO03	H	H	H	H					M		M	H
CLO04	H	H	H	H	M				H		M	H
CLO05	H	H	H	H	M				H		M	H

H=High, M=Medium, L=Low

3. ERISE Grid Mapping

Feature Enablement	**Level (1-5, 5 being highest)**
Entrepreneurship	2
Research	4
Innovation	3
Skills	5
Employability	5

4. Recommended Books:

Text Books

B01: Data Structures and Algorithms in Java, Robert Lafore, Sams Publishing, 2nd edition, 2002

B02: Data structures and algorithms in Java. John, Goodrich MT, Tamassia R, Goldwasser MH, wiley 2014

Reference Books

B03: Introduction to Algorithms by Thomas H. Cormen, The MIT Pressman 3rd Edition, 2001

B04: The textbook *Algorithms, 4th Edition* by Robert Sedgewick and Kevin Wayne, Pearson Education, Inc., 2011

E-Resources:

https://library.chitkara.edu.in/subscribed-books.php

5. Other readings and relevant websites:

Serial No	Link of Journals, Magazines, websites and Research Papers
1.	https://nptel.ac.in/courses/106/102/106102064/
2.	https://algs4.cs.princeton.edu/home/
3.	https://cse.iitkgp.ac.in/~dsamanta/joywithjava/data/slides/Chapter9.pdf
4.	https://onlinecourses.nptel.ac.in/noc22_cs92/preview

6. Recommended Tools and Platforms

Testpad, Apache NetBeans, Visual Studio

7. Course Plan:

Lecture Number	Topics	Text Book
1-2	Data Structures and Algorithms: Importance in programming and real-world applications, Elementary Data Organization, Data Structure Types and Operations Types: Linear vs Non-linear, Static vs Dynamic.	B01-Chapter-01
3-4	Algorithm: Complexity Analysis, Time vs Space trade-offs, Asymptotic Notations for Complexity(Ω, ω ,θ, O, o) Analysis, Operation counting, Iterative approach, Master theorem	B01-Chapter-02
5-6	Practice Problems for complexity computation	B01-Chapter-02
7-8	Array: Introduction, Representation of Linear Arrays in Memory, Traversing Linear Arrays, Insertion and Deletion in arrays. Processing Multi-Dimensional Arrays as Collection of 1-D arrays Applications in databases, caching, and matrix operations. Recursion and its applications	B01-Chapter-02
9-10	Searching: Linear and Binary Search with their Complexity Analysis	B02-Chapter10
	ST-01	
11-12	Sorting techniques: Selection Sort, Insertion Sort, Quick Sort, Merge Sort.	B01-Chapter-03, B04-Chapter-02
13-15	Linked List: Introduction & its memory representation, traversing a Linked List, Insertion into Linked List (sorted and unsorted Linked List), Deleting elements from Linked List, Operations on Doubly Linked List, Circular linked List & its applications	B01-Chapter-04
16-18	Stacks: Array representation of Stacks, implementation of stack using linked list.	B01-Chapter-05
19-21	Applications of Stack: Application in undo operations, Arithmetic Expressions, Polish Notation, Transforming Infix Expressions into Postfix Expressions, Implementations of recursive and non-recursive procedures by Stacks	B01-Chapter-04,05 B03-Chapter-05
	ST-02	

22-24	Queues: Representation as Array and Linked List Operations (insertion, deletion, and updation) in Queue, Practice Problems	B01-Chapter-04 B04-Chapter-01
25-26	Deques, Circular Queues, Priority Queues Operations: insertion, deletion, and updation, Practice problems	B01-Chapter-04 B03-Chapter10
27-28	Trees: Binary trees, complete binary trees, Binary Search Trees, Representing binary trees	B01-Chapter-8, B02-Chapter10
29-30	Tree and their Implementation, Tree Traversal: preorder, In order, Post order and their algorithms, Insertion, Deletion and Searching of elements in Binary Trees, Practice Problems	B01-Chpater-8, B02-Chapter10
End Term Examination		

8. Delivery/Instructional Resources

Lecture Numbers	Topics	Web References	Audio-Video References
1-2	Data Structures and Algorithms: Basic Terminology, Elementary Data Organization, Data Structures and Operations	https://portal.abuad.edu.ng/lecturer/documents/1604393139CSC_207-slide1-introduction_and_terminologies.pptx	https://ocw.mit.edu/courses/6-006-introduction-to-algorithms-spring-2020/resources/lecture-2-data-structures-and-dynamic-arrays/
3-4	Algorithm : Complexity, Time and Space & Complexity, Asymptotic Notations for Complexity(Ω, ω ,θ, O, o)	https://ocw.mit.edu/courses/1-204-computer-algorithms-in-systems-engineering-spring-2010/8ee75d49f1cb9a947f1d3f15a2aa9e00_MIT1_204S10_lec05.pdf	https://ocw.mit.edu/courses/6-006-introduction-to-algorithms-spring-2020/resources/lecture-1-algorithms-and-computation/
5-6	Practice Problems for complexity computation	https://cse.mait.ac.in/pdf/LAB%20MANUAL/DS.pdf	https://www.codechef.com/blogs/data-structures-in-java
7-8	Array: Introduction, Representation of Linear Arrays in Memory, Traversing Linear Arrays, Insertion and Deletion in arrays.	https://home.csulb.edu/~hill/ee444/Lectures%20-%20Deprecated/04%20C++%20Arrays%20Arduino.pdf	https://ocw.mit.edu/courses/6-006-introduction-to-algorithms-spring-2020/resources/lecture-2-data-structures-and-dynamic-arrays/
9-10	Searching: Linear and Binary Search with their Complexity.	https://courses.cs.washington.edu/courses/cse143/12wi/lectures/01-13/05-binarysearch-complexity.pdf	https://www.youtube.com/watch?v=k4xVQhMERuQ
11-12	Sorting techniques: Selection Sort, Insertion Sort, Quick Sort, Merge Sort.	https://ocw.mit.edu/courses/6-0001-introduction-to-computer-science-and-programming-in-python-fall-2016/resources/mit6_0001f16_lec12/	https://ocw.mit.edu/courses/6-006-introduction-to-algorithms-spring-2020/resources/lecture-5-linear-sorting/

13-15	Linked List: Introduction & its memory representation, traversing a Linked List, Insertion into Linked List (sorted and unsorted Linked List), Deleting from Linked List	https://web.stanford.edu/class/archive/cs/cs106b/cs106b.1188/lectures/Lecture16/Lecture16.pdf	https://www.youtube.com/watch?v=6wXZ_m3SbEs
16-18	Stacks: Array representation of Stacks, implementation of stack using linked list.	https://web.stanford.edu/class/archive/cs/cs106b/cs106b.1186/lectures/05-	https://www.youtube.com/watch?v=08QSylWv6jM
19-21	Applications of Stack: Application in undo operations, Arithmetic Expressions, Polish Notation, Transforming Infix Expressions into Postfix Expressions, Implementations of recursive and non-recursive procedures by Stacks	https://web.stanford.edu/class/archive/cs/cs106b/cs106b.1186/lectures/05-Stacks_Queues/5-Stacks_Queues.pdf	https://www.youtube.com/watch?v=XkLfiA7Xbks
22-24	Queues: Representation as Array and Linked List Operations (insertion, deletion, and updation) in Queue, Practice Problems	https://web.stanford.edu/class/archive/cs/cs106b/cs106b.1186/lectures/05-Stacks_Queues/5-Stacks_Queues.pdf	https://www.youtube.com/watch?v=XkLfiA7Xbks
25-26	Deques, Circular Queues, Priority Queues Operations: insertion, deletion, and updation, Practice problems	https://web.eecs.utk.edu/~bvanderz/teaching/cs140Fa10/notes/Queues/	https://www.youtube.com/watch?v=2zQtymZV6dk
27-28	Trees: Binary trees, complete binary trees, Binary Search Trees, Representing binary trees	https://ocw.mit.edu/courses/6-006-introduction-to-algorithms-spring-2020/resources/mit6_006s20_lec6/	https://ocw.mit.edu/courses/6-851-advanced-data-structures-spring-2012/resources/session-15-static-trees/
29-30	Tree and their Implementation, Tree Traversal: preorder, In order, Post order and their algorithms, Insertion, Deletion and Searching of elements in Binary Trees, Practice Problems	http://webdocs.cs.ualberta.ca/~holte/T26/tree-traversal.html	https://ocw.mit.edu/courses/6-006-introduction-to-algorithms-spring-2020/resources/lecture-6-binary-trees-part-1/

9. Lab Plan

Sr. No.	Lab Number	Experiments	Learning Resource
1	1-4	Introduction of Data structures and Algorithms: Operations of Data Structures	https://www.tutorialspoint.com/dsa_using_java/dsa_using_java_algorithms.htm
2.	5-9	Algorithm Complexity and Complexity Computation Calculate Time and Space complexity of algorithms	https://blog.geekster.in/time-complexity-in-java/
3.	10-20	Calculate the worst case, best case and average for each algorithm.	https://www.geeksforgeeks.org/analysis-algorithms-big-o-analysis/

		Describe each algorithm's overall performance using the possible class in Big-O notation.	
4.	21-28	Representation of Linear array in memory	https://www.geeksforgeeks.org/arrays-in-java/
5.	29-35	Implement sparse matrix using array.	https://www.geeksforgeeks.org/java-program-to-determine-if-a-given-matrix-is-a-sparse-matrix/
6.	36-42	Perform Linear Search and Binary Search on an array. Search the element by passing the array to a function and then returning the position of the element from the function	https://www.tutorialspoint.com/dsa_using_java/dsa_using_java_array.htm
7.	43-57	Sorting techniques: Selection Sort, Insertion Sort, Quick Sort, Merge Sort. Implementation of selection sort Implementation of Insertion sort Implementation of Quick sort Implementation of Merge sort	https://www.geeksforgeeks.org/sorting-algorithms/
8.	58-63	Create a linked list with nodes having information about a student and perform Insert a new node at specified position. Delete of a node with the roll number of student specified. Reversal of that linked list	https://www.geeksforgeeks.org/student-record-management-system-using-linked-list/
9.	64-71	Create a stack and perform Pop, Push, Traverse operations on the stack using Linear Linked list	https://www.geeksforgeeks.org/implement-a-stack-using-singly-linked-list/
10.	72-80	Implement insertion, deletion and display (inorder, preorder and postorder) on binary search tree	https://www.geeksforgeeks.org/binary-search-tree-traversal-inorder-preorder-post-order/
11.	81-102	The enqueue operation can be used to add the element to the rear of the queue. The dequeue operation can be used to removes the element from the front of the queues	https://www.geeksforgeeks.org/queue-implementation-using-linked-list-in-java/
12.	102-112	Create a Binary Tree Perform Tree traversals (Preorder, Postorder, Inorder)	https://www.geeksforgeeks.org/tree-traversals-inorder-preorder-and-postorder/

13.	113-120	Insertion, Deletion and Searching of element in Binary Tree	https://codingzap.com/binary-search-tree-java/

10. Action plan for different types of learners

Slow Learners	Average Learners	Fast Learners
• Remedial Classes on Saturdays • Encouragement for improvement using Peer Tutoring • Use of Audio and Visual Materials • Use of Real-Life Examples	• Workshops • Formative Exercises used to highlight concepts and notions • E-notes and E-exercises to read ahead of the pedagogic material.	• Engaging students to hold hands of slow learners by creating a Peer Tutoring Group • Design solutions for complex problems • Design solutions for complex problems • Presentation on topics beyond those covered in CHO

11. Evaluation Scheme & Components:

Evaluation Component	Type of Component	No. of Assessments	Weightage of Component	Mode of Assessment
Component 1	Testpad module progress and completion	-	10%	Online
Component 2	Sessional Test	03*	40%	Online
Component 3	End Term Examinations	01**	50%	Online
Total		100%		

*Students will have to appear in all Sessional Tests.

*Makeup Examination will compensate for either ST-1 or ST-2 (Only for genuine cases, based on the Dean's approval).

**As per Academic Guidelines, a minimum of 75% attendance is required to become eligible for appearing in the End Semester Examination.

12. Syllabus of the Course:

Subject: Data Structures / 22CS004	

S. No.	Topic (s)	No. of Sessions	Weightage %
1	**Data Structures and Algorithms**: Importance in programming and real-world applications, Elementary Data Organization, Data Structure Types and Operations **Types:** Linear vs Non-linear, Static vs Dynamic. **Algorithm :** Complexity Analysis, Time vs Space trade-offs, Asymptotic Notations for Complexity(Ω, ω ,θ, O, o) Analysis, Operation counting, Iterative approach, Master theorem Practice Problems for complexity computation **Array:** Introduction, Representation of Linear Arrays in Memory, Traversing Linear Arrays, Insertion and Deletion in arrays.	**52**	**34%**

	Processing Multi-Dimensional Arrays as Collection of 1-D arrays Applications in databases, caching, and matrix operations. Recursion and its applications **Searching:** Linear and Binary Search with their Complexity Analysis		
ST-1 (Covering 30% syllabus)			
2.	**Sorting techniques**: Selection Sort, Insertion Sort, Quick Sort, Merge Sort. **Linked List:** Introduction & its memory representation, traversing a Linked List, Insertion into Linked List (sorted and unsorted Linked List), Deleting elements from Linked List, Operations on Doubly Linked List, Circular linked List & its applications **Stacks:** Array representation of Stacks, implementation of stack using linked list. **Applications of Stack:** Application in undo operations, Arithmetic Expressions, Polish Notation, Transforming Infix Expressions into Postfix Expressions, Implementations of recursive and non-recursive procedures by Stacks **Queues:** Representation as Array and Linked List Operations (insertion, deletion, and updation) in Queue, Practice Problems.	**99**	**66%**
ST-2 (Covering 60% syllabus)			
3.	**Deques, Circular Queues, Priority Queues** **Operations**: insertion, deletion, and updation, Practice problems **Trees:** Binary trees, complete binary trees, Binary Search Trees, Representing binary trees **Tree and their Implementation, Tree Traversal:** preorder, In order, Post order and their algorithms, Insertion, Deletion and Searching of elements in Binary Trees, Practice Problems	**150**	**100%**
Sessional Test-3 (Project Based Evaluation)			
End Term 100% syllabus			

This Document is approved by:

Designation	**Name**	**Signature**
Course Coordinator	Dr. Heena Wadhwa	
Head-Academic Delivery	Dr. Mrinal Paliwal	
Dean	Dr. Rishu Chhabra	
Date	29.11.2024	