Course Plan

CHITKARA UNIVERSITY

A. Course Handout (For Students & Faculty)

Institute/School/College Name	Chitkara University Institute of Engineering & Technology		
Department/Centre Name	Department of Computer Science & Engineering		
Programme Name	Bachelor of Engineering- Computer Science & Engineering		
Course Name	Advanced Data Structures	Session	2023-2024
Course Code	CS192	**Semester/Batch**	6th / 2020
Lecture/Tutorial (Per Week)	2-0-4	**Course Credits**	4
Course Coordinator Name	Dr. Sunil Kumar Chawla		

1. Scope & Objective of the Course

The course provides a wide scope of learning & understanding of the subject and the main objectives of the course are

- To understand the detailed view of Arrays, Strings, Recursion, Backtracking.
- To learn object-oriented basics with strong up-skilling on various linear and non linear data structures.
- To explore and implement various algorithm design strategies using examples.
- To analyse and evaluate different data structures.
- To implement the concepts of data structures and algorithms by solving complex engineering problems and preparing well for interviews, competitions and hackathons.

2. Course Outcomes

At the end of the course, students will be able to:

CO1. Understand the detailed view of data structures and algorithms with underlying mathematics behind it.

CO2. Revisit Object Oriented fundamentals along with the concepts of other linear data structures like Linked lists and Stacks and non linear data structures like Graphs, Tries, Binary Trees and its variations; with main emphasis on Interview based questions.

CO3. Explore various algorithm strategies such as DP, Greedy Method, Backtracking and Bit-masking.

CO4. Analyse and evaluate different data structures and will be able to prepare well for Interview panels through numerical understanding of the concepts.

CO5. Implement the concepts of data structures and algorithms on several forums like code-chef, coding ninjas, GFG and Hacker Rank.

CLO-PO Mapping grid |Program outcomes (POs) are available as a part of Academic Program Guide

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	M	H	M		M				L	
CO2	H	M			H							
CO3	H	H	M		H	L						
CO4	M											
CO5	M	M	M	L	M		L		L			

3. Recommended Books (Reference Books/Textbooks)

RB1. Computer Algorithms by E. Horowitz, S. Sahni and S. Rajsekran, Computer Science Press, New York, ISBN – 0-7167-8316-9.

RB2. Introduction to Algorithms, Second Edition, Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, MIT Press, Cambridge, Massachusetts London, England McGraw-Hill Book Company, ISBN 0-262-03293-7.

RB3. Data Structures with C (Schaum's Outline Series) (English, Paperback, Lipschutz Seymour), McGraw Hill Education India, ISBN: 9780070701984, 9780070701984

RB4. Design & Analysis of Computer Algorithms (English, Paperback, Aho Alfred V.), Pearson Education India, ISBN: 9788131702055, 9788131702055

RB5. Data Structures and Algorithms Made Easy (English, Paperback, Karumanchi Narasimha), Karumanchi Narasimha, Careermonk Publications, ISBN: 9788193245279, 9788193245279.

4. Other readings & relevant websites

S.N.	Link of Journals, Magazines, Websites, and Research Papers
1.	https://onlinecourses.nptel.ac.in/noc22_cs26/preview
2.	https://www.youtube.com/watch?v=zWg7U0OEAoE
3.	https://iq.opengenus.org/list-of-advanced-data-structures/
4.	https://in.coursera.org/learn/advanced-data-structures
5.	https://www.geeksforgeeks.org/advanced-data-structures/
6.	https://www.youtube.com/@JennyslecturesCSIT/videos

5. Recommended Tools and Platforms: Windows 10 or higher / Ubuntu 21.04, GCC Compiler, IDE

6. Course Plan

Lecture No.	Topics	Recommended Books / Resources
1	Arrays – 1: Advance Problems on Sliding Windows and Two pointers will be discussed.	RB3
2	Arrays – 2: Discussion Frequency Arrays and Prefix Arrays and Its Problems.	RB4
3	Binary Search: Binary Search, Its Implementation and Advance Binary Search problems will be discussed.	RB1
4-5	Array Advanced Algorithms – 1: Kadane's Algorithm, Prime Seive, Vectors and Amalgamation of the above topics will be discussed.	RB2
6-7	Array Advanced Algorithms- 2: Problems on Sorting, Pigeon Hole Principle and Heavy Implementation will be discussed.	RB2
8-9	Strings: Implementation Problems on Strings, Two pointers in Strings and Problem on Frequency Arrays with respect to Strings.	RB2
10	Sliding Window – 1: Advance Problems on Sliding Window and Discussion of Deque STL.	RB2
11-12	Advanced String Algorithms: String Matching Algorithms like KMP, Z Function, and Rabin Karp will be discussed and problems based on that.	RB2
13-14	Array Interview Preparation class: Recently asked company problems based upon arrays, string and the above mentioned algorithms.	RB2, RB5
	Weekly Test-1 (Syllabus covered from Lecture 1 to 14)	
15-16	Recursion – 1: Basics of Recursion, basic problems on recursion to have better understanding of the call stack, Types of Recursion.	RB2, RB5
17-19	Recursion Backtracking – 1: Implementation based Problems on recursion will be discussed in a thorough manner with call stacks, Introduction to Backtracking and basic problem on backtracking to get the flow of it. Recursion Backtracking – 2: Advance problems on backtracking.	RB1, RB2, RB5
20	Recursion on Matrix: Discussion on how recursion and backtracking are used in general to solve problems on matrix/grid.	RB1, RB2, RB5
21-22	OOPS-1: Discussion on OOPs with real world example why it is important, Discussions on classes, objects and self invoked functions like Constructors, Copy Constructor, Copy Assignment Operators, Destructors.	RB4
23-24	OOPS-2: Discussion on characterises of OOPs like Encapsulation, Abstraction, Polymorphism, Inheritance, Dynamic Binding, Message Passing etc.	RB4
25	Linked List – 2: Interview Based Problems on LL.	RB2
	Weekly Test-2 (Syllabus covered from Lecture 15 to 25)	
26-27	Stack Interview Questions: Interview Problems Based on Stacks.	RB3
28-30	Binary Trees – 1: Binary Trees (Definition, Implementation, Algorithms on Trees (DFS, BFS, etc.),Standard Problems on Trees)	RB3, RB4
31-32	Binary Trees – 2: Interview Problems Based on Trees.	RB2
33-34	Binary Search Trees – 1: Implementation of BST, Standard Problems on BST.	RB1

35-36	Binary Search Trees – 2: Interview Problems Based on Trees.	RB4, RB5
37-38	Hash maps – 2: Advance Hashing Techniques, Interview Problems based Hashing etc.	RB2
39-40	Priority Queue – 2: Advance Problems on Heaps.	RB3
	Weekly Test-3 (Syllabus covered from Lecture 26 to 40)	
41	DP – 1: DP, Types of DP, Importance of DP, 1-D DP company oriented questions	RB2, RB4
42	DP – 2: Discussion on 2D DP and Grid DP and Advance Problems based on that.	RB2, RB3
43	DP – 3: Knapsack and Selecting Distinct based DP.	RB2, RB4, RB5
44	DP – 4: Problems based on DP Patterns.	GFG
45	DP – 5: Multi-dimensional DP	GFG
46	DP – 6: DP on Trees.	RB5, GFG
47	Greedy Algorithms – 2: Advance Problems on Greedy.	GFG
48	Bit-masking – 2: Interview Based Problems on Bit Manipulations.	GFG
49-50	Number Theory: Prime Sieve, Segmented Sieve, Euclid Algorithm, Extended Euclid Algorithm and Its Application in solving linear Diophantine equations and multiplicative modulo inverse, Totient Equation, Fermat Little Theoram etc.	RB2, GFG
51	Maths: Big Integers, Combinatorics, Solving Linear Recurrences, Mathematical Expectation etc.	GFG
	Weekly Test-4 (Syllabus covered from Lecture 41 to 51)	
52-53	Graphs-1: Undirected Graphs, Cycle Detection, shortest cycle in an undirected graphs etc, Directed Graphs, Topological sort, Cycle Detection in an directed graphs)	RB2, GFG
54-55	Graphs-2: Kosaraju algorithm, DSU and Problems based on the above mentioned topics.	RB2, RB5, GFG
56-57	Graphs-3: Minimum Spanning Trees, Kruskal's and Prism's Algorithm, Introduction to Weighted Graphs	RB2, RB5, GFG
58-59	Graphs-4: Dijkstras's, Bellman ford algorithms and Problems based on the above mentioned Topics.	RB2, RB5, GFG
60	Graphs-5: Advance problems on Graphs.	RB2, RB5, GFG
61	Tries: Introduction, Range Queries and Interview Problems on Tries.	RB2, RB5, GFG
62-64	Revision and Doubt Clearing Sessions	
Weekly Test-5 (Syllabus covered from Lecture 52 to 64)		
END TERM – FULL SYLLABUS		

7. Delivery/Instructional Resources

Lecture No.	**Topics**	**PPT** *(Link of ppts on the central server)*	**Industry Expert Session** *(If **yes**: link of ppts on the central server)*	**Web References**	**Audio-Video**
1-2	Arrays -1: Advance Problems on Sliding Windows and Two pointers will be discussed. Arrays - 2: Discussion Frequency Arrays and Prefix Arrays and Its Problems.			https://www.techiedelight.com/sliding-window-problems/ https://codeforces.com/blog/entry/66274#:~:text=Prefix%20array%20is%20a%20very,time%20complexity%20of%20your%20program.	
3-5	Binary Search: Binary Search, Its Implementation and Advance Binary Search problems will be discussed. Array Advanced Algorithms – 1: Kadane's Algorithm, Prime Seive, Vectors and Amalgamation of the above topics will be discussed.			https://www.thealgorists.com/Algo/BinarySearch/AdvancedBinarySearch https://www.geeksforgeeks.org/longest-sub-array-of-prime-numbers-using-segmented-sieve/	

6-9	Array Advanced Algorithms-2: Problems on Sorting, Pigeon Hole Principle and Heavy Implementation will be discussed. Strings: Implementation Problems on Strings, Two pointers in Strings and Problem on Frequency Arrays with respect to Strings.			https://medium.com/techie-delight/sorting-practice-problems-and-interview-questions-cff0b79f9cef https://www.geeksforgeeks.org/two-pointers-technique/	
10-12	Sliding Window - 1: Advance Problems on Sliding Window and Discussion of Deque STL. Advanced String Algorithms: String Matching Algorithms like KMP, Z Function, and Rabin Karp will be discussed and problems based on that.			https://codeforces.com/blog/entry/88880 https://www.scaler.com/topics/data-structures/z-algorithm/ https://www.geeksforgeeks.org/rabin-karp-algorithm-for-pattern-searching/	
13-14	Array Interview Preparation class: Recently asked company problems based upon arrays, string and the above mentioned algorithms.			https://www.geeksforgeeks.org/top-50-array-coding-problems-for-interviews/ https://www.geeksforgeeks.org/top-50-string-coding-problems-for-interviews/	
15-16	Recursion – 1: Basics of Recursion, basic problems on recursion to have better understanding of the call stack, Types of Recursion.			https://www.geeksforgeeks.org/recursive-functions/	
17-19	Recursion Backtracking – 1: Implementation based Problems on recursion will be discussed in a thorough manner with call stacks, Introduction to Backtracking and basic problem on backtracking to get the flow of it. Recursion Backtracking – 2: Advance problems on backtracking.			https://www.codingninjas.com/blog/2021/05/24/recursion-backtracking-algorithm-with-practice-problem/ https://www.geeksforgeeks.org/top-20-backtracking-algorithm-interview-questions/	
20	Recursion on Matrix: Discussion on how recursion and backtracking are used in general to solve problems on matrix/grid.			https://www.geeksforgeeks.org/traverse-a-given-matrix-using-recursion/	
21-22	OOPS-1: Discussion on OOPs with real world example why it is important, Discussions on classes, objects and self invoked functions like Constructors, Copy Constructor, Copy Assignment Operators, Destructors.			https://www.datatrained.com/post/oops-concepts-with-real-time-examples/#:~:text=Let's%20take%20an%20example%20of,of%20its%20attributes%20(data). https://en.cppreference.com/w/cpp/language/rule_of_three	
23-24	OOPS-2: Discussion on characterises of OOPs like Encapsulation, Abstraction,			https://www.geeksforgeeks.org/object-oriented-programming-in-cpp/	

	Polymorphism, Inheritance, Dynamic Binding, Message Passing etc.				
25-27	Linked List – 2: Interview Based Problems on LL. Stack Interview Questions: Interview Problems Based on Stacks.			https://www.geeksforgeeks.org/top-20-linked-list-interview-question/ https://medium.com/techie-delight/stack-data-structure-practice-problems-and-interview-questions-9f08a35a7f19	
28-30	Binary Trees – 1: Binary Trees (Definition, Implementation, Algorithms on Trees (DFS, BFS, etc.), Standard Problems on Trees)			https://www.geeksforgeeks.org/binary-tree-data-structure/	
31-36	Binary Trees – 2: Interview Problems Based on Trees. Binary Search Trees – 1: Implementation of BST, Standard Problems on BST. Binary Search Trees – 2: Interview Problems Based on Trees.			https://www.geeksforgeeks.org/top-50-tree-coding-problems-for-interviews/ https://www.javatpoint.com/binary-search-tree https://www.techiedelight.com/binary-search-tree-bst-interview-questions/	
37-40	Hashmaps-2: Advance Hashing Techniques, Interview Problems based Hashing etc. Priority Queue-2: Advance Problems on Heaps.			https://www.geeksforgeeks.org/top-20-hashing-technique-based-interview-questions/ https://www.hackerearth.com/practice/notes/heaps-and-priority-queues/	
41-46	DP-1: DP, Types of DP, Importance of DP, 1-D DP company oriented questions. DP-2: Discussion on 2D DP and Grid DP and Advance Problems based on that. DP-3: Knapsack and Selecting Distinct based DP. DP-4: Problems based on DP Patterns. DP-5: Multi-dimensional DP DP-6: DP on Trees.			https://www.hackerearth.com/practice/algorithms/dynamic-programming/introduction-to-dynamic-programming-1/tutorial/ https://www.scaler.com/topics/data-structures/2d-dp-problems/ https://www.geeksforgeeks.org/0-1-knapsack-problem-dp-10/ https://leetcode.com/discuss/general-discussion/458695/dynamic-programming-patterns https://www.upwork.com/resources/what-is-dynamic-programming https://itnext.io/introduction-to-multi-dimensional-dynamic-programming-666b095b2e7b	

				https://codeforces.com/blog/entry/20935	
47-48	Greedy Algorithms-2: Advance Problems on Greedy. Bit-masking-2: Interview Based Problems on Bit Manipulations.			https://www.interviewbit.com/courses/programming/bit-manipulation/	
49-51	Number Theory: Prime Sieve, Segmented Sieve, Euclid Algorithm, Extended Euclid Algorithm and Its Application in solving linear Diophantine equations and multiplicative modulo inverse, Totient Equation, Fermat Little Theoram etc. Maths: Big Integers, Combinatory, Solving Linear Recurrences, Mathematical Expectation etc.			https://www.geeksforgeeks.org/segmented-sieve/ https://www.geeksforgeeks.org/eudidean-algorithms-basic-and-extended/ https://www.geeksforgeeks.org/multiplicative-inverse-under-modulo-m/ https://www.geeksforgeeks.org/eulers-totient-function/ https://www.geeksforgeeks.org/fermats-little-theorem/ https://www.hackerearth.com/practice/math/combinatorics/basics-of-combinatorics/tutorial/ https://www.tutorialspoint.com/discrete_mathematics/discrete_mathematics_recurrence_relation.htm https://www.statisticssolutions.com/free-resources/directory-of-statistical-analyses/mathematical-expectation/	
52-60	Graphs-1: Undirected Graphs, Cycle Detection, shortest cycle in an undirected graphs etc, Directed Graphs, Topological sort, Cycle Detection in an directed graphs) Graphs-2: Kosaraju algorithm, DSU and Problems based on the above mentioned topics. Graphs-3: Minimum Spanning Trees, Kruskal's and Prism's Algorithm, Introduction to Weighted Graphs. Graphs-4: Dijkstra's, Bellman ford algorithms and Problems based on the above			https://www.geeksforgeeks.org/detect-cycle-undirected-graph/ https://www.geeksforgeeks.org/topological-sorting/ https://practice.geeksforgeeks.org/problems/strongly-connected-components-kosarajus-algo/1 https://www.geeksforgeeks.org/kruskals-minimum-spanning-tree-algorithm-greedy-algo-2/ https://www.geeksforgeeks.org/dijkstras-shortest-path-algorithm-greedy-algo-7/	

	mentioned Topics. Graphs-5: Advance problems on Graphs.			https://www.geeksforgeeks.org/bellman-ford-algorithm-dp-23/ https://www.codingninjas.com/codestudio/library/important-graph-problems-for-interviews-advanced-problems	
61-64	Tries: Introduction, Range Queries and Interview Problems on Tries. Revision and Doubt Clearing Sessions			https://www.geeksforgeeks.org/introduction-to-trie-data-structure-and-algorithm-tutorials/	

8. Action plan for different types of learners

Slow Learners	Average Learners	Fast Learners
• Multiple Remedial Extra Classes • Encouragement for improvement using Peer Tutoring	• Doubt-sessions • Pre-coded algorithms to illustrate concepts and notions • E-notes and E-exercises to study in addition to available pedagogic material	• More Practice assignments on real life problems • Engaging students to hold hands of slow learners by creating a Peer Tutoring Group • Participation in Hackathons, coding competitions etc.

9. Evaluation Scheme & Components

Evaluation Component	Type of Component	No. of Assessments	Weightage of Component	Mode of Assessment
Component 2	Sessional Tests (STs)	05*	40%	Offline
Component 3	End Term Examination	01	60%	Offline
Total		**100%**		

* Out of 05 STs, best 3 STs for final marks evaluation of STs will be considered.

Evaluation Components

Type of Assessment	Timeline of Conduct	Total Marks	Question Paper Format			
			1 Mark MCQ	2 Mark MCQ	5 Mark Question	10 Mark Question
Sessional Test 1 / Weekly Test 1 / Formative Assessment 1	Week 4	40	0	0	04	02
Sessional Test 2 / Weekly Test 2 / Formative Assessment 2	Week 6	40	0	0	04	02
Sessional Test 3 / Weekly Test 3 / Formative Assessment 3	Week 8	40	0	0	04	02
Sessional Test 4 / Weekly Test 4 / Formative Assessment 4	Week 10	40	0	0	04	02
Sessional Test 5 / Weekly Test 5 / Formative Assessment 5	Week 11	40	0	0	04	02
End Term Examination		60	06	02	06	02

10. Details of Evaluation Components

Evaluation Component	Description	Syllabus Covered (%)	Timeline of Examination	Weightage (%)
Component 02	ST 01	Up to 20%	As defined in Academic Calendar	40%
	ST 02	20% - 40%	As defined in Academic Calendar	
	ST 03	40% - 60%	As defined in Academic Calendar	

	ST 04	60% - 87%	As defined in Academic Calendar	
	ST 05	88% - 100%	As defined in Academic Calendar	
Component 03	End Term Examination *	100%	At the end of the semester	60%
Total				**100%**

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

11. Syllabus of the Course

Subject: Advanced Data Structures	**Subject Code: CS192**	
Topic (s)	**No. of Lectures**	**Weightage %**
Arrays – 1	7	5%
Arrays – 2		
Binary Search		
Array Advanced Algorithms – 1		
Array Advanced Algorithms- 2		
Strings	7	5%
Sliding Window – 1		
Advanced String Algorithms		
Array Interview Preparation class		
Recursion – 1	6	5%
Recursion Backtracking – 1		
Recursion Backtracking – 2		
Recursion on Matrix		
OOPS-1	4	5%
OOPS-2		
Linked List – 2	2	5%
Stack Interview Questions	1	5%
Binary Trees – 1	8	5%
Binary Trees – 2		
Binary Search Trees – 1		
Binary Search Trees – 2		
Hashmaps – 2	5	5%
Priority Queue – 2		
DP – 1	6	20%
DP – 2		
DP – 3		
DP – 4		
DP – 5		
DP – 6		
Greedy Algorithms – 2	2	5%
Bitmasking – 2		4%
Number Theory	3	6%
Maths		
Graphs-1	9	20%
Graphs-2		
Graphs-3		
Graphs-4		
Graphs-5		
Tries	4	5%

Useful Resources:

http://www.beehyve.io/ - this is a community of CS students studying the same topics

http://www.geeksforgeeks.org/ - explains all the high level fundamentals

https://visualgo.net/en - has visualizations of a lot of helpful algorithms

International Courses:

CS 226 Algorithms and Data Structures: http://www.cs.princeton.edu/courses/archive/fall14/cos226/info.php

Brown CS 16 - Introduction to Algorithms and Data Structures: http://cs.brown.edu/courses/cs016/

Stanford CS 166 Data Structures: http://web.stanford.edu/class/cs166/

University of Washington, St. Louis (CSE241) Algorithms and Data Structures:

http://classes.engineering.wustl.edu/cse241/

Harvard CSE 22 Data Structures: http://sites.fas.harvard.edu/~cscie22/

Michigan EECS 281 Data Structures and Algorithms:

http://web.eecs.umich.edu/~sugih/courses/eecs281/syllabus.html

Cornell CS 2110 OO Programming and Data Structures: http://www.cs.cornell.edu/courses/cs2110/2016fa/

MiT 6.006 Introduction to Algorithms: https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-006-introduction-to-algorithms-spring-2008/

Important links:

https://www.udemy.com/course/learning-data-structures-and-algorithms/
https://www.coursera.org/specializations/data-structures-algorithms
https://hackr.io/tutorials/learn-data-structures-algorithms
https://www.edx.org/course/algorithms-and-data-structures
https://www.codingninjas.com/courses/onlline-c-plus-plus-course
https://swayam.gov.in/nd1_noc20_cs85/preview
https://www.niit.com/india/short-term-courses/information-technology/data-structures-and-algorithms
https://practice.geeksforgeeks.org/courses/dsa-self-paced
https://www.youtube.com/playlist?list=PL2_aWCzGMAwI3W_JlcBbtYTwiQSsOTa6P
https://www.youtube.com/channel/UCu4ztYtW-Bg1KIfcLAULtVQ
https://nptel.ac.in/courses/106/102/106102064/
https://www.swayamprabha.gov.in/index.php/program/archive/13
https://www.youtube.com/playlist?list=PL2_aWCzGMAwI3W_JlcBbtYTwiQSsOTa6P
https://swayam.gov.in/nd2_cec19_cs04/preview

This document is approved by:

Designation	Name	Signature
Course Coordinator	Dr. Sunil Kumar Chawla	
Program Head	Dr. Susheela Hooda	
Cluster Dean	Dr. Rupali Gill	
Dean (Academics Affairs)	Dr. Rajnish Sharma	
Date (DD/MM/YYYY)	16/02/2023	