MANIPAL UNIVERSITY JAIPUR

School of Computing and IT

Department of Computer and Communication Engg.

Course Hand-out

Data Structures | CS1303 | 4 Credits | 3 1 0 4

Session: July 19 – Nov 19 | Faculty: Manoj K Bohra | Class: III CCE

A. Introduction: This course is offered by Computer Science and Engg. Dept., targeting students who wish to pursue development and research in industries or higher studies in field of Computer Science, IT and Communication Engineering. This course will form the base of computer science and engineering and hence this course is introduced at this level to make the students understand various ways of organizing data and storing it into memory and use the type depending upon the application.

B. Course Outcomes: At the end of the course, students will be able to

[CS1303.1] explain basic concepts of various data structures

[CS1303.2] describe how arrays, linked lists, stacks, queues, trees and graphs are represented in memory and their operations

[CS1303.3] select and/or apply appropriate data structures to solve problems and assess the trade-offs involved in the design choices.

[CS1303.4] describe and analyze various sorting algorithms like bubble, selection ,insertion, merge sort, heap sort and quick sort

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

[PO.1] Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

[PO.2] Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3] Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified

needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4] Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5] Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6] The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7] Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8] Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9] Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10] Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11] Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12] Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

[PSO.1] Should be able to clearly understand the basic principles, concepts and applications in the field of computer based Communication/networking, information

sharing, signal processing, web based systems, smart devices and communication technology.

[PSO.2] Should be able to nail down the issues prevalent in the field of Computer and Communication Engineering.

[PSO.3] Should be able to identify the existing open problems in the field of computing and propose the best possible solutions.

[PSO.4] Should be able to apply the contextual knowledge in the field of computing and communication to assess social, health, safety and cultural issues and endure the consequent responsibilities relevant to the professional engineering practice.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Closed Book)	15
	Sessional Exam II (Closed Book)	15
	In class Quizzes and Assignments , Activity feedbacks (Accumulated and Averaged)	30
End Term Exam (Summative)	End Term Exam (Closed Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. SYLLABUS

Introduction: Algorithm specification; **Performance Analysis**: Time and Space Complexity, Asymptotic notation; pointer declaration and definition, memory allocation functions, array of pointers; The type definition, enumerated types, accessing structures, complex structures, arrays of structures, structures and functions; Recursive definition & processes, Recursion in C, writing recursive programs efficiency of recursion, Examples: Tower of Hanoi, GCD, Fibonacci Definition and examples, Representing **Stacks** in C, Evaluation of expressions, multiple stacks and queues; Applications: infix, postfix and prefix and their conversions. **Linked lists** representations, Singly, doubly, header node, circular, Applications: linked stacks and queues, polynomial and long integer arithmetic, union, intersection, Basic terminologies, binary tree representation, recursive/ non recursive, Binary search tree, AVL trees; **Applications**: Expression **Trees**, inserting, deleting, searching, height of BST Terminology and representations, **Graph** operations, spanning trees, minimum cost spanning tree, shortest path and transitive closure, Binary and linear search, insertion, quick, merge, heap, radix sort Static Hashing.

F. TEXT BOOKS

T1. Aaron M. Tenenbaum, Yedidyah Langsam, Moshe J. Augenstein, "*Data Structures using C*", Pearson Education, 2013.

G. REFERENCE BOOKS

R1. Ellis Horowitz, Sartaj Sahni and Susan Anderson-Freed, *"Fundamentals of Data Structures in C"*, University Press (India) Pvt. Ltd., 2014.

R2. Alfred V. Aho, John E. Hopcroft and Jeffrey D. Ullman, "*Data Structures and Algorithms*", Pearson Education, 2012

R3. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, " *Introduction to algorithms*", PHI, Third Edition, 2009

R4. Seymour Lipschutz, "*Data Structures with C* (Schaum's Outline Series)", McGraw Hill Education Private Limited, 2011.

R5. Mark Allen Weiss, *"Data structures and Algorithm Analysis in C"*, Pearson, Second edition, 2014.

H. LECTURE PLAN

Lec No	Major Topics	Topics	Session Outcome	Mode of Delivery	Corresponding CO	Mode Of Assessing CO
1.	**Introduction**	Introduction to data structures, Algorithm Specifications, How to Write Algorithms	define data structure and list various data structure.	Lecture	CS1303.1	Class Quiz End Term
2.		Performance Analysis- Time and Space Complexity, Asymptotic Analysis, Example , Functions in 'C', Example Programs on Functions	analyze time complexity of simple algorithms.	Lecture	CS1303.1 CS1303.1	Class Quiz Home Assignments I Sessional End Term
3.	**Arrays**	Example Programs on Functions, Arrays : Introduction, Single Dimensional Arrays : Declaration, Initialization, Operations (Insertion and Deletion of Element)	define arrays and apply knowledge on single dimensional arrays in writing programs.	Lecture	CS1303.1 CS1303.2	Class Quiz Home Assignments I Sessional End Term
4.		Searching in Single Dimensional Arrays – Selection Sort, Linear and Binary Search	construct searching and sorting algorithms and write programs using single dimensional arrays.	Lecture	CS1303.2	Class Quiz Home Assignments I Sessional End Term
5.		Multidimensional Arrays, Two	explain row major and column major	Lecture	CS1303.1	Class Quiz

		Dimensional Arrays : Declaration, Initialization, Addition of Two Matrices, Row Major and Column Major Representation	memory allocation in 2-D arrays, Apply knowledge on two dimensional arrays in writing programs		CS1303.2	Home Assignments I Sessional End Term
6.		Example Programs on Two Dimensional Arrays, Row Major and Column Major Representation	apply knowledge on two dimensional arrays in writing programs.	Lecture	CS1303.2 CS1303.3	Class Quiz Home Assignments I Sessional End Term
7.		Pointers : Introduction, Example Programs on Pointers, Pointers and Arrays, Dynamic Memory Allocation	illustrate dynamic memory allocation using pointers in solving problems requiring list of values.	Lecture	CS1303.1 CS1303.2	Class Quiz Home Assignments I Sessional End Term
8.		Dynamic Memory Allocation: Dynamic Array creation, Dynamic structure creation.	apply knowledge on pointers in writing programs.	Lecture	CS1303.1 CS1303.2	Class Quiz Home Assignments I Sessional End Term
9.		Problems solving by students on array	analyze the applicability of array as appropriate Data Structure to solve the problem and develop an algorithm/program to provide the solution to a given problem through it.	Tutorial	CS1303.3	Class Quiz Home Assignments I Sessional End Term
10.		Problems solving by students on array	structure mapping and model a given real world problem into array.	Tutorial	CS1303.3	Class Quiz Home Assignments I Sessional End Term

11.	**Linked List**	Linked List : Introduction, Basic Terminologies, Advantages over Arrays, Applications, Structures in 'C', Example Programs on Structures and pointer to Structure	describe linked list data structure, disadvantages of array based storage and need of linked list data structure, develop structures in 'C' and dealing it with pointers.	Lecture	CS1303.1 CS1303.2	Class Quiz Home Assignments I Sessional End Term
12.		Passing Structures to Functions, Singly Linked List : Introduction , Operations	pass structures to functions, to explain self-referential structures and functions, describe linked list storage structure and basic operations.	Lecture	CS1303.1 CS1303.2	Class Quiz Home Assignments I Sessional End Term
13.		Singly Linked List : Operations (Continued)	implement singly linked list storage structure and basic operations (insertion, deletion and searching) defined over it.	Lecture	CS1303.1 CS1303.2	Class Quiz Home Assignments I Sessional End Term
14.		Circular Linked List : Introduction, Operations	understand and implement circular linked list storage structure and basic operations (insertion, deletion and searching) defined over it.	Lecture	CS1303.1 CS1303.2	Class Quiz Home Assignments I Sessional End Term
15.		Doubly Linked List : Introduction, Operations	understand and implement circular linked list storage structure and basic operations (insertion, deletion and searching) defined over it.	Lecture	CS1303.1 CS1303.2	Class Quiz Home Assignments I Sessional End Term
16.		Some Example Programs on Linked List	implement linked list operations like reversing a linked list, finding middle of the list, sorting a list etc.	Lecture	CS1303.3	Class Quiz Home Assignments I Sessional

						End Term
17.		Problems solving by students on linked list	analyze the applicability of linked list as appropriate Data Structure to solve the problem and develop an algorithm/program to provide the solution to a given problem through it.	Tutorial	CS1303.3	Class Quiz Home Assignments I Sessional End Term
18.		Problems solving by students on linked list	structuring, mapping and model a given real world problem into linked list.	Tutorial	CS1303.3	Class Quiz Home Assignments I Sessional End Term
19.	**Stacks**	Recursive Functions, Example Programs on Recursive Functions, Stack : About, Applications	explain the working philosophy of stack and how the system stack stores local function calls.	Lecture /Expert -Lecture	CS1303.1 CS1303.3	Class Quiz Home Assignments II Sessional End Term
20.		Stack : Operations, Implementation of Stack using Array and Linked List	develop a stack based application and realize the stack functioning using arrays as well as linked list and compare their implementations.	Lecture /Expert -Lecture	CS1303.1 CS1303.2	Class Quiz Home Assignments II Sessional End Term
21.		Expression Notations : Polish Notation, Reverse Polish Notation, Infix Notation, Evaluation of Expression written in Polish Notation	explain various forms of mathematical notations to express an expression and their evaluation	Lecture	CS1303.3	Class Quiz Home Assignments II Sessional End Term
22.		Evaluation of Expression written in Reverse Polish Notation Evaluation of Expression written in	evaluate the postfix(infix) expression using stacks	Lecture	CS1303.3	Class Quiz Home Assignments

		Infix Notation				II Sessional End Term
23.		Conversion of Expression from one Notation to Another	explain how to realize a mathematical expression using stacks and to convert an infix expression to postfix notation using stack.	Lecture	CS1303.3	Class Quiz Home Assignments II Sessional End Term
24.		Conversion of Expression from one Notation to Another	convert an infix expression to prefix notation using stack	Lecture	CS1303.3	Class Quiz Home Assignments II Sessional End Term
25.		Problems solving by students on stack applications	develop recursive code, to handle the problem using stacks, to analyze the applicability of stack with respect to a given problem	Tutorial	CS1303.3	Class Quiz Home Assignments II Sessional End Term
26.	**Queues**	Linear Queue : Introduction, Applications, Operations, Implementation using Array and Linked List	explain Queue Data structure, its application in real world and its operations enqueue and dequeue, to implement queue data structure using array and linked list.	Lecture	CS1303.1 CS1303.2	Class Quiz Home Assignments II Sessional End Term
27.		Circular Queue : About, Applications, Operations, Implementation using Array and Linked List	explain Circular Queue Data structure, its application in real world and its operations enqueue and dequeue	Lecture	CS1303.1 CS1303.2	Class Quiz Home Assignments II Sessional End Term
28.		Priority Queue and Deques : About, Applications, Operations,	explain Priority Queue Data structure and Deques, its application in real world and its	Lecture	CS1303.1 CS1303.2	Class Quiz Home

		Implementation using Array and Linked List	operations enqueue and dequeue.			Assignments II Sessional End Term
29.		Problems solving by students on queue applications	analyze the applicability of queue as appropriate Data Structure to solve the problem, to develop an algorithm/program to provide the solution to a given problem through it.	Tutorial	CS1303.3	Class Quiz Home Assignments II Sessional End Term
30.	**Trees**	Trees : Introduction , Basic Terminology, Types of Trees, Binary Search Tree : Creation, : Searching an Element , Insertion of Node	describe about binary tree (BT), tree-terminology, types of BT, creation of Binary Search Tree, search operations	Lecture	CS1303.1 CS1303.2	Class Quiz Home Assignments II Sessional End Term
31.		Binary Search Tree : Deletion of Node, Determining Height	describe about deletion of a node in BST and computing height	Lecture	CS1303.2	Class Quiz Home Assignments II Sessional End Term
32.		Binary Search Tree : Traversal (In-order, Pre-order and Post- order)	explain different traversal in BST	Lecture	CS1303.2	Class Quiz Home Assignments II Sessional End Term
33.		Threaded Binary tree : Introduction, Creation , Insertion of Node, Deletion of Node and Traversal of Tree	describe about Threaded Binary tree, its applications and operations	Lecture	CS1303.1 CS1303.2	Class Quiz Home Assignments End Term
34.		AVL Tree : Introduction , Applications	describe drawbacks of BST, Use of AVL tree,	Lecture	CS1303.1	Class Quiz

		Creation , Searching an Element, Insertion of Node	how to insert a value in AVL and then required rotations (LL, RR , LR and RL)		CS1303.2	Home Assignments End Term
35.		AVL Tree : Deletion of Node	describe how to delete a node from AVL tree and then required rotations	Lecture	CS1303.2	Class Quiz Home Assignments End Term
36.		Heaps : Insertion of Node , Binary Heap: Creation, Insertion of Element, Deletion of Element	describe what is heap, types, creations of max and min heaps, heap sort, use of heap in priority queue implementation	Lecture	CS1303.1 CS1303.2	Class Quiz Home Assignments End Term
37.		Problems solving by students on tree and its use	construct BST and AVL tree from given sequence of values	Tutorial	CS1303.3	Class Quiz Home Assignments End Term
38.		Problems solving by students on tree and its use	construct heap from given sequence of values and implement priority queue	Tutorial	CS1303.3	Class Quiz Home Assignments End Term
39.	**Graphs**	Graphs : Introduction, Basic Terminology, Applications, Representation of Graphs : Adjacency Matrix Representation	describe representation of graph in term of adjacency matrix with their complexity	Lecture	CS1303.1 CS1303.2	Class Quiz Home Assignments End Term
40.		Representation of Graphs : Adjacency List Representation	describe representation of graph in term of adjacency list with their complexity	Lecture	CS1303.1 CS1303.2	Class Quiz Home Assignments End Term
41.		Graph Traversal : Breadth First Traversal, Depth First Traversal	conceptualize on the various methods of graph traversal and understand the concept	Lecture	CS1303.2	Class Quiz Home

			of Queue and Stack data structure			Assignments End Term
42.		Minimum Spanning Tree, Prims Algorithm, Kruskal's Algorithm	understand the application of graph such as TSP problem	Lecture	CS1303.2	Class Quiz Home Assignments End Term
43.		Shortest Path Algorithms: Dijkstra's Algorithm, Floyd's Algorithm	understand the application of graph such as computer networking(Routing System)	Lecture	CS1303.2	Class Quiz Home Assignments End Term
44.		Problems solving by students on graph algorithms	find shortest path using Dijkstra's Algorithm and Floyd's Algorithm for a given graph	Tutorial	CS1303.3	Class Quiz Home Assignments End Term
45.		Problems solving by students on graph algorithms	find MST using Prims Algorithm and Kruskal's Algorithm for a given graph	Tutorial	CS1303.3	Class Quiz Home Assignments End Term
46.	**Searching & Sorting**	Sorting : Introduction, Bubble Sort, Insertion Sort	describe the concept of sorting with various sorting algorithm	Lecture	CS1303.1	Class Quiz Home Assignments End Term
47.		Sorting (Continued) : Quick Sort, Merge Sort	describe the application of sorting such as medical monitoring	Lecture	CS1303.1 CS1303.4	Class Quiz Home Assignments End Term
48.		Sorting (Continued) : Radix Sort , Heap Sort	describe the concept of priority queue with the help of heap sort	Lecture	CS1303.1 CS1303.4	Class Quiz Home Assignments

						End Term
49.		Hashing : Introduction, Applications, Hash Functions	describe different hashing techniques/functions	Lecture	CS1303.1 CS1303.2 CS1303.4	Class Quiz Home Assignments End Term
50.		Hash Collisions, Collision Resolution : Open Addressing, Chaining	describe different collision resolving techniques with examples	Lecture	CS1303.1 CS1303.2	Class Quiz Home Assignments End Term
51.		Problems solving by students on soring and its application	develop program for searching and sorting	Tutorial	CS1303.3	Home Assignments End Term
52.		Problems solving by students on hashing and its application	develop program for hashing	Tutorial	CS1303.3	Home Assignments End Term

A. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES			
		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	PSO 3	PSO 4
CS 1303.1	explain basic concepts of various data structures	3	2										2	3			1
CS 1303.2	describe how arrays, linked lists, stacks, queues, trees and graphs are represented in memory and their operations		1	2									2		2	2	
CS 1303.3	select and/or apply appropriate data structures to solve problems and assess the trade-offs involved in the design choices.		1	2									2		2	2	
CS 1303.4	describe and analyze various sorting algorithms like bubble, selection ,insertion, merge sort, heap sort and quick sort		1	2									2	2		1	

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation