MANIPAL UNIVERSITY JAIPUR

School of Information Security & Data Science

DEPARTMENT OF DATA SCIENCE & ENGINEERING

Course Hand-out

Data Structures & Algorithms | DSE 2101 | 1 Credits | 3 1 0 4

Session: July 24 – Nov 24 | Faculty: Dr. Chirag Joshi, Dr. Rekha Chaturvedi, Mr. Deevesh Choudhary, Ms. Meenakshi Gaur |
Class: B.Tech CSE (DSE) III Semester

A. **Introduction:** This course is offered by Department of Data Science and Engineering, targeting students who wish to pursue development and research in industries or higher studies in field of Data Science. This course will form the base of Data Science 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:

[DSE 2101.1] Understand the performance analysis of algorithms with their applications.

[DSE 2101.2] Illustrate basic concept of data structure operations such as traversing, insertion, deletion, searching and sorting.

[DSE 2101.3] Describe arrays, linked lists, stacks, queues, trees, and graphs are their representation in memory.

[DSE 2101.4] Perform various operations on different data structures and to solve real time problems.

[DSE 2101.5] Analyse and compare various searching and sorting algorithms, and assess the trade-offs involved in the design choices to develop employability skills.

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 <u>professional ethics</u> and responsibilities and norms of the engineering practices.

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

[PO.10]. **Communication**: <u>Communicate effectively</u> 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 <u>life-long learning</u> in the broadest context of technological change.

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

[PSO.1] Understand the role of the mathematical, statistical, and AI techniques in the field of data science & engineering.

[PSO.2] Apply the acquired knowledge and expertise to perform data analytics tasks for multidimensional data sets.

[PSO.3] Develop effective and scalable industrial solutions for real world socio-economic problems using data analytics tools and techniques.

D. **Assessment Plan:**

Criteria	Description		Maximum Marks
Internal Assessment (Summative)	Continuous Assessments	MTE 30 Marks Assignment-10 Marks Quiz-20 Marks	60
Exam (Summative)	Exam (Exam)	ETE-40 Marks	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 miss a lab 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 2 throughout the entire semester.	

Introduction: Algorithm Specification; **Performance Analysis**: Time and Space Complexity, Asymptotic Notation; **C Concepts**: Pointers, Functions, Arrays, Passing Arrays to Functions through Pointers, Dynamic Memory Allocation, Bubble Sort, Insertion Sort, Selection Sort, Structures, Arrays of Structures, Passing Structures to Functions; **List:** ADT, Array and its Types, Implementation, Operations, Linked List and its Types, Implementation and Operations; **Stack:** ADT, Implementations using Array and Linked List, Operations and its Applications; **Queue:** ADT, Implementations using Array and Linked List, Operations and its Applications; **Tree:** Terminologies, Different Types, Representation of Binary Tree using Array and Linked Structure, Binary Search Tree, Different Operations (Recursive and Non-Recursive), Heap, Heap Sort, Priority Queue, AVL Trees, B-Tree; **Graph:** Introduction, Representation, Operations and Applications; **Searching Techniques And Hashing.**

Textbooks:
1. Aaron M. Tenenbaum, Yedidyah Langsam, Moshe J. Augenstein, "Data Structures using C", Pearson Education, 2013.

References Books:
1. Ellis Horowitz, Sartaj Sahni and Susan Anderson-Freed, "Fundamentals of Data Structures in C", University Press (India) Pvt. Ltd., 2014.
2. Alfred V. Aho, John E. Hopcroft and Jeffrey D. Ullman, "Data Structures and Algorithms", Pearson Education, 2012.
3. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, "Introduction to algorithms", PHI, Fourth Edition, 2022.
4. Seymour Lipschutz, "Data Structures with C (Schaum's Outline Series)", McGraw Hill Education Private Limited, 2011.
5. Mark Allen Weiss, "Data structures and Algorithm Analysis in C", Pearson, Second edition, 2014.

F.   **Lecture Plan:**

Class Number	Topics	Session Outcome	Mode of Delivery	Corresponding Course Outcome	Mode of Assessing the Outcome
1.	**Introduction**: Algorithm Specification;	define data structure and list various data structure.	Lecture	**DSE 2101.1**	Class Quiz MTE, End Term, Home Assignment
2.	**Performance Analysis:** Time and Space Complexity, Asymptotic Notation;	analyze time complexity of simple algorithms.	Lecture	**DSE 2101.1**	Class Quiz MTE, End Term, Home Assignment
3.	**C Concepts:** Pointers, Functions	illustrate pointers in solving problems requiring list of values.	Lecture	**DSE 2101.1**	Class Quiz MTE, End Term, Home Assignment
4.	**C Concepts:** Functions	Define Array and passing of array through functions and pointers	Lecture	**DSE 2101.1**	Class Quiz MTE, End Term,

						Home Assignment
5.	**Arrays,** Passing Arrays to Functions through Pointers	Understanding the passing of array through functions	Lecture	**DSE 2101.2**	Class Quiz MTE, End Term, Home Assignment
6.	Dynamic Memory Allocation	apply knowledge on pointers in writing programs.	Lecture	**DSE 2101.1**	Class Quiz MTE, End Term, Home Assignment
7.	Bubble Sort	describe the concept of sorting with various sorting algorithm	Lecture	**DSE 2101.2**	Class Quiz MTE, End Term, Home Assignment
8.	Insertion Sort	describe the concept of sorting with various sorting algorithm	Lecture	**DSE 2101.2**	Class Quiz MTE, End Term, Home Assignment
9.	Selection Sort, Structures	describe the concept of sorting with various sorting algorithm and introduction to structures	Lecture	**DSE 2101.2**	Class Quiz MTE, End Term, Home Assignment
10.	Arrays of Structures, Passing Structures to Functions	Define array of structures and passing of structure through functions	Lecture	**DSE 2101.3**	Class Quiz MTE, End Term, Home Assignment
11.	**List:** ADT, Array and its Types	Understanding of array declaration and its types	Lecture	**DSE 2101.3**	Class Quiz MTE, End Term, Home Assignment
12.	Implementation, Operations	Define various operations of array	Lecture	**DSE 2101.4**	Class Quiz MTE, End Term, Home Assignment
13.	Linked List and its Types	Define linked list and its types	Lecture	**DSE 2101.3**	Class Quiz MTE, End Term, Home Assignment

14.	Implementation and Operations	Implement various operations of Linked List	Lecture	**DSE 2101.4**	Class Quiz MTE, End Term, Home Assignment
15.	**Stack:** ADT, Implementations using Array	Understanding Stack declaration and its implementation using array	Lecture	**DSE 2101.3**	Class Quiz MTE, End Term, Home Assignment
16.	Implementations using Linked List	Illustrate the implementation of stack using linked list	Lecture	**DSE 2101.2**	Class Quiz MTE, End Term, Home Assignment
17.	Operations and its Applications	Define various operations of Stack	Lecture	**DSE 2101.4**	Class Quiz MTE, End Term, Home Assignment
18.	**Queue:** ADT, Implementations using Array	explain Queue Data structure, its application in real world and its operations enqueue and dequeue, to implement queue data structure using array	Lecture	**DSE 2101.3**	Class Quiz MTE, End Term, Home Assignment
19.	Implementations using Linked List	Implementation of queue using linked list	Lecture	**DSE 2101.2**	Class Quiz MTE, End Term, Home Assignment
20.	Operations and its Applications	Define different operations of queue	Lecture	**DSE 2101.4**	Class Quiz MTE, End Term, Home Assignment
21.	**Tree:** Terminologies, Different Types	describe about binary tree (BT), tree-terminology, types of BT	Lecture	**DSE 2101.3**	Class Quiz, End Term, Home Assignment
22.	Representation of Binary Tree using Array and Linked Structure	Illustrate various representation of BT using array and linked list	Expert Lecture for application of all data structures	**DSE 2101.2**	Class Quiz, End Term, Home Assignment
23.	Binary Search Tree	creation of Binary Search Tree, search operations	Lecture	**DSE 2101.2**	Class Quiz, End Term,

					Home Assignment
24.	Different Operations (Recursive)	Define recursive operations using BST	Lecture	**DSE 2101.3**	Class Quiz, End Term, Home Assignment
25.	Different Operations (Non-Recursive)	Define non recursive operations using BST	Lecture	**DSE 2101.3**	Class Quiz, End Term, Home Assignment
26.	Heap	Understanding heap and its types	Lecture	**DSE 2101.2**	Class Quiz, End Term, Home Assignment
27.	Heap Sort	Define heap sort algorithm and its complexity	Lecture	**DSE 2101.2**	Class Quiz, End Term, Home Assignment
28.	Priority Queue	Define priority queue and its use	Lecture	**DSE 2101.2**	Class Quiz, End Term, Home Assignment
29.	AVL Trees	Understanding of AVL tree and its properties	Lecture	**DSE 2101.2**	Class Quiz, End Term, Home Assignment
30.	AVL Trees Operations	Define various operations of AVL tree	Lecture	**DSE 2101.3**	Class Quiz, End Term, Home Assignment
31.	Practice Problem on AVL Tree Operations	Define various rotations of AVL tree	Lecture	**DSE 2101.5**	Class Quiz, End Term, Home Assignment
32.	B-Tree	Understanding of B-Tree	Lecture	**DSE 2101.2**	Class Quiz, End Term, Home Assignment
33.	B-Tree Operations	Define various operations of AVL tree	Lecture	**DSE 2101.3**	Class Quiz, End Term, Home Assignment
34.	Practice Problem on B-Tree Operations	Solving problems involving B-Trees	Lecture	**DSE 2101.5**	Class Quiz, End Term, Home Assignment

35.	**Graph:** Introduction,	Define Graph and its types	Lecture	**DSE 2101.3**	Class Quiz, End Term, Home Assignment
36.	Representation	Illustrate the representation of Graph	Lecture	**DSE 2101.2**	Class Quiz, End Term, Home Assignment
37.	Operations and Applications	Define operations and applications of graph	Lecture	**DSE 2101.4**	Class Quiz, End Term, Home Assignment
38.	**Searching Techniques**- Introduction	Understanding of Searching techniques	Lecture	**DSE 2101.2**	Class Quiz, End Term, Home Assignment
39.	Linear Search	Define linear search and its complexity	Lecture	**DSE 2101.2**	Class Quiz, End Term, Home Assignment
40.	Binary Search	Define Binary Search and its complexity	Lecture	**DSE 2101.2**	Class Quiz, End Term, Home Assignment
41.	**Hashing-**Introduction	Understanding of Hashing	Lecture	**DSE 2101.2**	Class Quiz, End Term, Home Assignment
42.	**Hashing**- why we need hashing	Define the reason for hashing	Lecture	**DSE 2101.3**	Class Quiz, End Term, Home Assignment
43.	**Hashing-**Type of Hashing Techniques	Illustrate various type of hashing techniques	Lecture	**DSE 2101.3**	Class Quiz, End Term, Home Assignment
44.	Practice Problems on Hashing	Practice problems to understand hashing	Lecture	**DSE 2101.5**	Class Quiz, End Term, Home Assignment
45.	Revision and Practice	Solving doubt of students	Lecture	**DSE 2101.5**	Class Quiz, End Term, Home Assignment
46.	Revision and Practice	Solving doubt of students	Lecture	**DSE 2101.5**	Class Quiz, End Term,

					Home Assignment
47.	Revision and Practice	Solving doubt of students	Lecture	**DSE 2101.5**	Class Quiz, End Term, Home Assignment
48.	Revision and Practice	Solving doubt of students	Lecture	**DSE 2101.5**	Class Quiz, End Term, Home Assignment

H. Course Articulation Matrix: (Mapping of COs with POs & PSOs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES (POs)												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES (PSOs)			
		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	
[DS 2101.1]	Understand the performance analysis of algorithms with their applications.	3	2										2	3			
[DS 2101.2]	Illustrate basic concept of data structure operations such as traversing, insertion, deletion, searching and sorting.		1	2									2	1			
[DS 2101.3]	Describe arrays, linked lists, stacks, queues, trees, and graphs are their representation in memory.		1	2									2	1	1		
[DS 2101.4]	Perform various operations on different data structures and to solve real time problems.		1	2									2	2	1		
[DS 2101.5]	Analyse and compare various searching and sorting algorithms, and assess the trade-offs involved in the design choices to develop employability skills.		2	2	1								2	1	1		

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