MIT | Academy of Engineering (An Autonomous Institute Affiliated to Savitribai Phule Pune University)	COURSE SYLLABUS	
SCHOOL OF COMPUTER ENGINEERING	W.E.F	AY: 2024 - 2025 (Rev. 2023 (NEP))
SECOND YEAR BACHELOR OF TECHNOLOGY COMPUTER ENGINEERING [SOFTWARE ENGINEERING]	COURSE NAME	ADVANCE DATA STRUCTURES
	COURSE CODE	2310219T
	COURSE CREDITS	2
RELEASE DATE : 01/07/2024	REVISION NO.	2.1

TEACHING SCHEME (HOURS/WEEK)		EXAMINATION SCHEME AND MARKS					
		THEORY			LABORATORY		TOTAL
LECTURE	PRACTICAL	IA	MSE	ESE	CA	PRACT/DEMO/PRES.	
2	NIL	15	20	40	NIL	NIL	75

PREREQUISITE KNOWLEDGE: Data Structures

COURSE OBJECTIVES:

2310219T.CEO.1: Introduce various data structures like trees, graphs, heaps, hash tables, disjoint sets etc.

2310219T.CEO.2: Demonstrate how to select appropriate data structures based on requirement of application.

2310219T.CEO.3: Discuss about the implementation of various real world applications using data structures.

2310219T.CEO.4: Explain about the evaluation of performance of data structures in terms of time and space complexity.

2310219T.CEO.5: Learn how to design own data structure using standard data structures.

COURSE OUTCOMES :

After successful completion of the course, students will be able to,

2310219T.CO.1: Illustrate the working of advanced data structures namely trees, graphs, heaps,d isjoint sets, hash tables, probabilistic data structures[L3].

2310219T.CO.2: Demonstrate the advantages and disadvantages of various data structures [L3].

2310219T.CO.3: Choose appropriate data structures to build applications for given real world problem statements [L3].

2310219T.CO.4: Develop various applications for specified problems using data structures such as trees, graphs and heaps [L3].

2310219T.CO.5: Evaluate performance of various data structures in terms of time and space complexity [L4].

2310219T.CO.6: Design own data structures using the built in data structures [L4].

COURSE ABSTRACT:

A good algorithm usually comes together with a set of good data structures that allow the algorithm to manipulate the data efficiently. The course Advance Data structures focuses on developing important technical concepts in the theories and practical applications of Data structures. Students will delve into the fundamental concepts of Trees, Balanced Trees, Graphs, Heaps, Disjoint sets, Hashing, Probabilistic data structures.

THEORY COURSE CONTENTS

UNIT 1	**TREES**	**09 HOURS**

Applications/Case Study: Parse trees and expression trees in Compiler.

Contents: Introduction to trees, Tree Terminology, General trees, Binary trees, KD tree, Tree as ADT, Conversion of general tree into binary tree, Representation of tree using sequential and linked list, Binary tree and its types, Properties of Binary trees, Binary search tree and operations on binary search tree, Depth First and Breadth First traversal, Tree traversal techniques: inorder, preorder, postorder traversal (recursive and non-recursive traversal),Threaded Binary Tree-concept, Operations on TBT(insert, delete, search, update and traversal), Time complexity and space complexity for tree operations, Applications of trees.

Self Study: Game trees

Further Readings: Optimal Binary Search Tree.

UNIT 2	**HEIGHT BALANCED AND MULTIWAY TREES**	**06 HOURS**

Applications/Case Study: BTRFS File System.

Contents: Height balanced trees concepts ,Types of height balanced trees and applications, AVL Trees and operations, Multiway trees: concepts, Types of multiway trees: B and B+ Trees operations on multiway trees and applications, Time complexity and space complexity for tree operations.

Self Study: Red Black Tree ,Trie Tree, Splay Tree.

Further Readings:: AA Trees and range queries..

UNIT 3	GRAPHS	05 HOURS

Applications/Case Study: Packet routing in networks.

Contents: Graph Concepts, Terminology,Storage representation, Adjacency matrix, adjacency list, adjacency multi list, inverse adjacency list. Traversals - depth first and breadth first, Minimum spanning Tree, Prims and Kruskal Algorithms, Dikjtra's Single source and multi-source shortest path, Topological ordering applications of graphs.

Self Study: Warshall's algorithm..

Further Readings: Algorithms for connected components.

UNIT 4	HEAPS AND DISJOINT SETS	05 HOURS

Applications/Case Study: APriority queue.

Contents: Concept of Heaps, Types of heap, Operations on Heap – insert, delete, up-heapify and downheapify, use of heap in heap-sort, Fibonacci heap. Concept of Disjoint Sets, Disjoint Sets as ADT, Up Trees, Smart Union and Path compression.

Self Study: Binomial heap

Further Readings: Multidimensional Heaps.

UNIT 5	PROBABILISTIC DATA STRUCTURES	05 HOURS

Applications/Case Study: Recommendation System

Contents: Probabilistic data structures concept and Types of Probabilistic data structures: Membership Bloom Filters, Cuckoo Filters, Cardinality: Linear counting, HyperLogLog, Frequency: Count-Min Sketch , Similarity: Minhash, SkipLists , Applications of Probabilistic data structure structures.

Self Study: Counting Bloom Filter.

Further Readings: q-digest and t-digest data structures for ranking.

TEXT BOOKS

1. Horowitz, Ellis, Sartaj Sahni, and Dinesh Mehta. (2008). *Fundamentals of data structures.* 2^{nd} Edition, Universities Press . ISBN 978-8173716065.
2. Samanta, Debasis. (2009). *Classic data structures.* 2^{nd} Edition, Prentice Hall India. ISBN 978-8120337312.
3. Brass, Peter. (2014). *Advanced data structures.* 2^{nd} Edition, Cambridge University Press. ISBN 978-1107439825.

REFERENCE BOOKS

1. Cormen, Thomas H., et al.(2009). *Introduction to Algorithms.* 3^{rd} Edition, MIT Press. ISBN: 978-0262533058.
2. Gakhov, Andrii (2019). *Probabilistic Data Structures and Algorithms for Big Data Applications.* ISBN:978-3748190486

E-RESOURCES

1. https://nptel.ac.in/courses/106102064
2. https://nptel.ac.in/courses/106106133
3. https://www.cse.iitb.ac.in/ ranade/cs213/
4. https://ocw.mit.edu/courses/6-851-advanced-data-structures
5. https://www.cs.bham.ac.uk/ jxb/DSA/dsa.pdf
6. https://www.cs.jhu.edu/ jason/226/
7. https://courses.csail.mit.edu/6.851/spring21/

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SECOND YEAR BACHELOR OF TECHNOLOGY COMPUTER ENGINEERING [SOFTWARE ENGINEERING]	COURSE NAME	ADVANCE DATA STRUCTURES LAB
	COURSE CODE	2310219L
	COURSE CREDITS	1
RELEASE DATE : 01/07/2024	REVISION NO.	2.1

TEACHING SCHEME (HOURS/WEEK)		EXAMINATION SCHEME AND MARKS					
		THEORY			LABORATORY		TOTAL
LECTURE	PRACTICAL	IA	MSE	ESE	CA	PRACT/DEMO/PRES.	
NIL	2	NIL	NIL	NIL	20	30	50

PREREQUISITE KNOWLEDGE: Data Structures

COURSE OBJECTIVES:

2310219L.CEO.1: Introduce various data structures like trees, graphs, heaps, hash tables, disjoint sets etc.

2310219L.CEO.2: Demonstrate how to select appropriate data structures based on requirement of application.

2310219L.CEO.3: Discuss about the implementation of various real world applications using data structures.

2310219L.CEO.4: Explain about the evaluation of performance of data structures in terms of time and space complexity.

2310219L.CEO.5: Learn how to design own data structure using standard data structures.

COURSE OUTCOMES :

After successful completion of the course, students will be able to,

2310219L.CO.1: Choose appropriate data structures for solving a given problem statement [L3].
2310219L.CO.2: Develop functions to implement various operations to be performed using appropriate data structures [L3].
2310219L.CO.3: Demonstrate advantages and disadvantages of various data structures [L3].
2310219L.CO.4: Implement program for given real world problem using suitable data structures [L3].
2310219L.CO.5: Analyze the efficiency of different data structures for specified problem statement[L4].

COURSE ABSTRACT:

A good algorithm usually comes together with a set of good data structures that allow the algorithm to manipulate the data efficiently. The course Advance Data structures focuses on developing important technical concepts in the theories and practical applications of Data structures. Students will delve into the fundamental concepts of Trees, Balanced Trees, Graphs, Heaps, Disjoint sets, Hashing, Probabilistic data structures.

PRACTICALS

PRACTICAL NO.01	**BINARY SEARCH TREE**	**6 HOURS**
Design and develop a program in C++ to implement the following operations on Binary Search Tree: create, inorder traversal, preorder traversal, postorder traversal(for both recursive and non-recursive),delete a node, insert a node and level wise printing.		
PRACTICAL NO.02	**THREADED BINARY TREE**	**4 HOURS**
Write a program in C++ to implement the following operations on Threaded Binary Tree : create, inorder traversal, preorder traversal, postorder traversal, inorder traversal, preorder traversal, postorder traversal(both recursive and non-recursive) .		
PRACTICAL NO.03	**AVL TREE**	**6 HOURS**
Write a program in C++ to implement the following operations on AVL Trees: create, recursive inorder traversal, recursive preorder traversal, recursive postorder traversal, non recursive inorder traversal, non recursive preorder traversal, non recursive postorder traversal.		
PRACTICAL NO.04	**MINIMUM SPANNING TREE.**	**4 HOURS**
Write a program in C++ to find the minimum spanning tree of a given graph using Prim's and Kruskal's algorithm.		
PRACTICAL NO.05	**HEAPS**	**4 HOURS**
Write a program in C++ to implement heap sort algorithm to sort the given numbers in ascending and descending order		
PRACTICAL NO.06	**PROBABILISTIC DATA STRUCTURES**	**6 HOURS**
Write a program in C++ to implement the following probabilistic data structures Bloom's Filter, and count-min sketch.		

TEXT BOOKS

1. Horowitz, Ellis, Sartaj Sahni, and Dinesh Mehta. (2008). *Fundamentals of data structures.* 2^{nd} Edition, Universities Press . ISBN 978-8173716065.
2. Samanta, Debasis. (2009). *Classic data structures.* 2^{nd} Edition, Prentice Hall India. ISBN 978-8120337312.
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4. https://ocw.mit.edu/courses/6-851-advanced-data-structures
5. https://www.cs.bham.ac.uk/ jxb/DSA/dsa.pdf
6. https://www.cs.jhu.edu/ jason/226/
7. https://courses.csail.mit.edu/6.851/spring21/