Birla Institute of Technology and Science, Pilani,
Hyderabad Campus
Department of Computer Sc. and Information Systems
First Semester 2022-2023
BITS F232 (Foundations of Data Structures and Algorithms)

Date: 29th August 2022

Course Number : BITS F232 (L:3, P:1, U:4) M, W, F: 8th hour
Course Title : Foundations of Data Structures and Algorithms
Instructor-In-Charge : Prof. Chittaranjan Hota (hota[AT]hyderabad.bits-pilani.ac.in)
Instructors : Dr. Lov Kumar, Dr. Aneesh Chivukula

Scope and Objectives of the Course:

A data structure is a collection of large amounts of data values, the relationships among them, and the functions or operations that can be applied on them. In order to be effective, data has to be organized in a manner that adds to the effectiveness of an algorithm, and data structures such as stacks, queues, linked lists, heaps, trees, and graphs provide different capabilities to organize and manage large amounts of data. While developing a program or an application, many developers find themselves more interested in the type of algorithm used rather than the type of data structure implemented. However, the choice of data structure used for a particular algorithm is always of paramount importance. For example, B-trees have unique abilities to organize indexes and hence are well suited for implementation of databases; Linked lists are well suited for backtracking algorithms like, accessing previous and next pages in a web browser; Tries are well suited for implementing approximate matching algorithms like, spell checking software or predicting text in dictionary lookups on Mobile phones; Graphs are well suited for path optimization algorithms (like in Google maps) or searching in a Social graph (like Facebook). As computers have become faster and faster, the problems they must solve have become larger and more complex, requiring development of more complex programs. This course will also teach students good programming and algorithm analysis skills so that they can develop such programs with a greater degree of efficiency.

The primary objectives of the course are as under:

- Apply various basic data structures such as stacks, queues, linked lists, trees etc. to solve complex programming problems. Understand basic techniques of algorithm analysis.
- Design and implement advanced data structures like graphs, balanced search trees, hash tables, priority queues etc. Apply graph and string algorithms to solve

real world problems like finding shortest paths on huge maps or detecting plagiarism percentage.

- Apply basic algorithmic techniques such as brute-force, greedy algorithms, divide and conquer, dynamic programming etc. to solve complex programming problems and examine their efficiency.

At the end of the course, you should understand common data structures and algorithms, be able to develop new data abstractions (interfaces) and use existing library components in C++.

Reference Books:

R1: Data Structures and Algorithms in C++, Michael T. Goodrich, Roberto Tamassia, David M. Mount, 2nd Edition, 2011, Wiley (e-book in India).
R2: Introduction to Algorithms, TH Cormen, CE Leiserson, RL Rivest, C Stein, 3rd Ed., MIT Press, PHI, 2010.
R3: Data Structures & Algorithm Analysis in C++, Mark Allen Weiss, 4th Edition, Pearson, 2014.
R4: Data Structures and Algorithms, Alfred V. Aho, John E. Hopcroft, Jeffrey D. Ullman, 4th Indian reprint, Pearson, 2001.

Lecture Plan:

Lecture#	Learning Objectives	Topics to be covered	Chapter in the Text Book
1	The role of DS and Algorithms in Computing.	What kinds of problems are solved by algorithms? Journey from problems to programs.	R2 (1), R4(1)
2	Introduction to C++.	Classes: Class Structure, Constructors, Class Friends and Class Members, Standard Template Library (STL), An example C++ program.	R1 (1.5, 1.6)
3-4	To understand the features of Object Oriented Paradigm.	Object Oriented Design: Goals, Principles and Design Patterns; Inheritance and Polymorphism; Interfaces and abstract classes; Templates.	R1 (2.1, 2.2, 2.3)
5-7	Implementing elementary data structures and algorithms.	Using arrays, Insertion and removal from a Linked list, generic single linked list, doubly linked lists, circular linked lists, linear and binary recursion.	R1 (3.1, 3.2, 3.3, 3.5)
8-9	Understanding techniques for Algorithm analysis.	Functions: Linear, N-Log-N, Quadratic functions etc., Asymptotic notation and asymptotic analysis, Using Big-Oh notation, Examples of analysis.	R1 (4.1, 4.2), R2 (2, 3)

10-12	Implementing more common data structures and algorithms like Stacks, Queues, Deques, Vectors, List ADTs, Sequences, and Trees. Using Amortization to perform a set of push operations on a vector.	Stack ADT, Array-based stack implementation, stack implementation using generic linked list, Applications of stacks: matching tags in an HTML document; Queue ADT, Array-based and circular linked list based implementation.	R1 (5.1, 5.2)
13		Double-Ended queue: Deque ADT, Implementing using doubly linked lists, Adapters: Implementing stack using Deque.	R1 (5.3)
14		Vector ADT, Simple Array-based implementation; Extendable array based implementation (Amortization) and STL Vectors.	R1 (6.1)
15-16		List ADT: Node based operations and Iterators, doubly linked list implementation, Sequence ADT, Applications: Bubble sort on sequences, and its analysis.	R1 (6.2, 6.3, 6.4)
17-18		General Trees: Properties and functions, Traversal algorithms: Pre order, post order traversals, Binary tree: ADTs, Linked and Vector structures for Binary trees, Binary tree traversal, Template function pattern.	R1 (7.1, 7.2, 7.3)
19-21	Implementing Advanced data structures like Priority queues, Heaps, Hash tables, Maps, Skip lists, Dictionaries, Search Trees.	Priority Queue ADT, Implementing using Lists, Algorithms suitable for Priority queues, Heap: Complete binary trees and their representation, Implementing Heaps using Priority queue, Heap sort as an example.	R1 (8.1, 8.2, 8.3)
22-24		Map ADT, Implementation using Lists, Hash tables: Bucket arrays, hash functions, compression functions, collision-handling schemes, Rehashing into a new table, Implementation of hash tables, Skip lists: Search and update operation implementations.	R1 (9.1, 9.2, 9.4)
25		Dictionary ADT: Implementation with location-aware entries.	R1 (9.5)
26-28		Binary Search Trees: Operations and Analysis, AVL Trees: Insertion and deletion, Analysis, Multi-way search trees, Red-Black Trees: Operations and analysis.	R1 (10.1, 10.2, 10.4, 10.5)
29-30	Understanding various basic	Merge sort: Divide and conquer, merging arrays and lists, running time of merge sort; Quick sort: Randomized quick sort.	R1 (11.1, 11.2)

31-33	Algorithmic techniques and usage of appropriate data structures along with their applications and analysis.	Sorting through algorithmic lens: Lower bound, Linear time: Bucket and Radix sort, Comparing sorting algorithms.	R1 (11.2, 11.3)
34-35		Strings and Dynamic programming: String operations, Matrix Chain-Product as an example, Applying Dynamic programming to LCS problems.	R1 (12.1, 12.2)
36-37		Pattern matching algorithms: Brute force, Boyer-Moore algorithm, KMP algorithm, Pattern matching using Tries.	R1 (12.3)
38-39		Graph Algorithms: Graph ADT, Data structures for graphs: Edge list, Adjacency list, Adjacency matrix.	R1 (13.1, 13.2)
40		Graph Traversals: DFS, and BFS, Traversing a Diagraph, Transitive closure.	R1 (13.4)
41-42		Shortest path and MST: Dijkstra, Kruskal, and Prim-Jarnik algorithms.	R1 (13.5, 13.6)

Evaluation Scheme:

Component	Duration	Weightage (%)	Date & Time	Nature of the component
Mid sem Test	90 min	30%	05/11 1.30 - 3.00PM	Closed Book
Lab Test (One)	1 hr.	20%	To be announced	Open Book
Programming Assignments(5)	-	15%	To be announced	Take home
Comprehensive examination	180 min.	35%	18/12 FN	Part Open

Note: minimum 40% of the evaluation to be completed by midsem grading.

Make-up-Policy:

Make-up exams will be strictly granted on prior permission and on genuine grounds only. A request email should reach the I/C on or before the test.

Course Notices and Material:

Course material pertaining to this course will be made available on a regular basis on the course webpage in googleclass page and will be used for notices, announcements, grades, quizzes, and googlemeet recordings. Programming assignments will have a demo/ viva monthly once.

Consultation Hour:

To be announced in the class.

Academic Honesty and Integrity Policy:

Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

Instructor-In-Charge, BITS F232