# Lahore University of Management Sciences

# CS202/EE202 – Data Structures

Spring 2016

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| Instructor | Dr. Ihsan Ayyub Qazi |
| Class Timings | 4:30pm-5:45pm, Monday/Wednesday |
| Room No. | SBASSE 9-114A, Computer Science Department, LUMS |
| Office Hours | TBA |
| Email | ihsan.qazi@lums.edu.pk |
| Telephone | +92 42 3560 8368 |
| Teaching Assistants (TAs) | TBA |
| Course URL | LMS (https://lms.lums.edu.pk) |

| Course Basics | | | | |
|---|---|---|---|---|
| Credit Hours | 3 credit hours | | | |
| Lecture(s) | 2 Per Week | | Duration | 75 mins |
| Tutorial (per week) | 1 Per Week | | Duration | 60 mins |

| Course Distribution | |
|---|---|
| Core | CS Majors, EE Majors, and CS Minors |
| Elective | All |
| Open for Student Category | All |
| Close for Student Category | None |

## COURSE DESCRIPTION

Data structures are essential building blocks for designing efficient algorithms. Thus, they play a central role in computer science and are important in many areas of electrical engineering, computational biology, computational finance, etc. They are used in a variety of applications today including search engines (e.g., Google, Bing), social networking applications (e.g., Facebook, Twitter), embedded systems (e.g., cell phones, robots), and DNA analysis. This course will introduce the fundamentals of data structures and will provide a thorough understanding of how to systematically organize data in a computer system. In addition, this course will introduce students to analytical tools for comparing data structures in terms of their time and space complexities. Moreover, students will appreciate the importance of programming structures, abstractions, and algorithms for improving the efficiency of computer programs.

## COURSE PREREQUISITE

- CS 200 Introduction to Programming

## COURSE OBJECTIVES

- To understand the design of fundamental data structures as well as algorithms that operate on them
- To understand the fundamental tradeoffs in the design of the data structures
- To introduce tools for analyzing the time and space complexity of data structures
- To provide rigorous 'hands-on' experience with implementing different data structures in a programming language

## Learning Outcomes

- Students will be able to understand basic data structures
- Students will become aware of how data structures are used in real-world applications
- Students will understand the fundamental tradeoffs that exist in the design of data structures
- Students will be able to compare the time and space efficiency of different data structures
- Students will be able to appreciate how changing application requirements can lead to new data structures
- Students will be able to write programs to efficiently manipulate, store, and retrieve data

## Grading Breakup and Policy

Programming Assignment(s) + Homeworks: 30%
Quiz(s): 20%
Midterm Examination: 20%
Final Examination: 30%

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| Examination Detail | |
|---|---|
| Midterm Exam | Yes/No: Yes<br>Duration: 3 hours<br>Preferred Date: TBA<br>Exam Specifications: TBA |
| Final Exam | Yes/No: Yes<br>Duration: 3 hours<br>Exam Specifications: TBA |

Textbook(s)/Supplementary Readings

**Required Textbooks**

- **(GTM)** Data Structures and Algorithms in C++ by Michael T. **G**oodrich, Roberto **T**amassia, and David **M**ount (2nd Edition)
- **(Weiss)** Data Structures and Algorithm Analysis in C++ by Mark Allen **Weiss** (2nd Edition)

| Session | Topics | Recommended Readings |
|---|---|---|
| 1 | Overview: Data Structures, Abstract Data Types, and Applications | |
| 2 | Analysis Tools: Experimental Analysis, Asymptotic Notation | (GTM) Chapters 4.1-4.2 + (Weiss) Chapter 6 |
| 3 | Analysis Tools: Asymptotic Analysis, Arrays | (GTM) Chapters 3.1-3.4 + (Weiss) Chapters 16 |
| 4 | Arrays, Lists (Singly Linked List, Doubly Linked List), Stacks | Above + (GTM) Chapters 5.1+(Weiss) Chapter 17, 16 |
| 5 | Stacks, Queues | (GTM) Chapters 5.1-5.3 + (Weiss) Chapter 16 |
| 6 | Trees: Foundations, Tree Traversals | (GTM) Chapters 7.1, 7.2 + (Weiss) Chapter 18.1 |
| 7 | Trees: Tree Traversals, Binary Trees | Above + (GTM) Chapters 7.3 + (Weiss) Chapter 18.4 |
| 8 | Binary Trees: Analysis, Applications | (GTM) Chapters 7.3 + (Weiss) Chapter 18.2, 18.3 |
| 9 | Binary Search Trees (BST): Basics, BST Analysis | (GTM) Chapters 10.1 + (Weiss) Chapter 19.1-19.3 |
| 10 | Balanced Binary Trees: AVL Trees | (GTM) Chapters 10.2 + (Weiss) Chapter 19.4 |
| 11 | Balanced Binary Trees: AVL Trees, Red-Black Trees (optional) | (GTM) Chapters 10.5 + (Weiss) Chapter 19.4, 19.5 |
| 12 | Hash Tables: Hash Functions | (GTM) Chapters 9.2 + (Weiss) Chapter 20.1, 20.2 |
| 13 | Hash Tables: Chaining, Open Addressing | (GTM) Chapters 9.2 + (Weiss) Chapter 20.3 |
| 14 | **Midterm Exam** | |
| 15 | Priority Queues: Foundations, Binary Heaps | (GTM) Chapters 8.1-8.3 + (Weiss) Chapter 21.1 |
| 16 | Heaps: Binary Heaps, HeapSort | (GTM) Chapters 8.3 + (Weiss) Chapter 21.1, 21.2 |
| 17 | Sorting: Insertion Sort, Selection Sort, Mergesort | (GTM) Chapters 11.1 + (Weiss) Chapter 9.1-9.5 |
| 18 | Sorting: Quicksort, Bucket-Sort, Radix-Sort (optional) | (GTM) Chapters 11.2, 11.3 + (Weiss) Chapter 9.6-9.8 |
| 19 | Data Compression: Applications, Huffman Coding | (GTM) Chapters 12.4 + (Weiss) Chapter 13.1 + Notes |
| 20 | Tries: Standard, Compressed, Suffix Tries | (GTM) Chapters 12.5 |
| 21 | Graphs: Basics, Data Structures for Graphs | (GTM) Chapters 13.1, 13.2 + (Weiss) Chapter 15.1 |
| 22 | Graph Traversals: Depth First Search, Breadth First Search | (GTM) Chapters 13.3 + (Weiss) Chapter 15.2 |
| 23 | Weighted Graphs: Minimum Spanning Trees, Topological Sort | (GTM) Chapters 13.6 + (Weiss) Chapter 15.5 |
| 24 | Weighted Graphs: Directed Graphs, Connected Components | (GTM) Chapters 13.4, 13.5 + (Weiss) Chapter 15.5 |
| 25 | Shortest-Path Algorithms: Dijkstra's Algorithm | (GTM) Chapters 13.5 + (Weiss) Chapter 15.3 |
| 26 | Network Flow Problem, Advanced DS: Distributed Hash Tables | Slides/Notes |
| 27 | Advanced DS: Bloom Filters, Memory Locality | Slides/Notes |
| 28 | Advanced DS: Parallel Algorithms/DS + Course Review | Slides/Notes |