# CIS 1210: Data Structures and Algorithms

**Course Lecture Notes** 

CIS 1210 Course Staff \*

Draft of: April 4, 2023

University of Pennsylvania

 $<sup>^*</sup>$  see acknowledgments on next page

#### Goal

There is no one book that covers everything that we want to cover in CIS 1210. The goal of these notes is for students to find all course lecture material in one place, and in one uniform format.

### Acknowledgments

These lecture notes were compiled by CIS 1210 Course Staff, including Steven Bursztyn, Rajiv Gandhi, John Geyer, and Robin Tan for CIS 1210 at the University of Pennsylvania.

These lecture notes are a work in progress, and we appreciate the students and Head TAs who have helped make small edits.

Some chapters include attributions to other courses or textbooks from which we adapted our lecture notes, with some parts copied directly.

We also gratefully acknowledge the many others who made their course materials freely available online.

#### Disclaimer

These notes are designed to be a supplement to the lecture. They may or may not cover all the material discussed in the lecture (and vice versa).

Material varies from semester to semester, and this book may contain more information than what will be covered in lecture (i.e., material you may not be responsible for knowing). Please refer to the course website for assigned readings.

#### **Errata**

If you find any mistakes, please email the professor(s) and Head TAs so we can fix them.

#### Feedback

If you believe a certain topic is explained poorly, or could use additional examples or explanations, please reach out to the course staff. As mentioned, this is a work in progress and we would love to do what we can to make this resource as helpful as possible.

## Table of Contents

Table of Contents			111	
1	Rev	Review of Terms, Proofs, and Probability		
	1.1	Review of Proofs and Proof Techniques	1	
		Induction	2	
	1.2	Graphs	3	
		Trees	4	
		Eulerian and Hamiltonian Graphs	5	
	1.3	Probability	6	
	1.4	Linearity of Expectation	8	
	1.5	Probability Distributions	9	
		The Geometric Distribution	10	
		Binomial Distributions	11	
		Examples	13	
2	Gal	le-Shapley Stable Matching	15	
	2.1	Background and Intuition	15	
	2.2	Formulating the Problem	15	
	2.3	Examples	17	
	2.4	Designing an Algorithm	18	
	2.5	Runtime of the GS Algorithm	19	
	2.6	Correctness of the GS Algorithm	19	
	2.7	Extensions	21	
3	Greatest Common Divisor			
	3.1	Definitions	24	
	3.2	Calculating the GCD	24	
	3.3	Correctness of Euclid's Algorithm	26	
	3.4	Runtime of Euclid's Algorithm	27	
4	Insertion Sort			
	4.1	Insertion Sort	29	
	4.2	Correctness of Insertion Sort	30	
	4.3	Running Time of Insertion Sort	30	
5	Rui	nning Time and Growth Functions	32	
	5.1	Measuring Running Time of Algorithms	32	
	5.2	RAM Model of Computation	32	
	5.3	Average Case and Worst Case	32	