

Department of Computer Science Ashoka University

Discrete Mathematics: CS1104-2

Semester: Spring 2023

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Much of the course notes, presentations, and other material used in this course have been lifted from the contents generously shared by Prof. Soumyottam Chatterjee who had taught this course in earlier semesters at the Computer Science Department at Ashoka University.

1 Overview

Discrete mathematics is the study of mathematical structures that can be considered *discrete* (in a way analogous to discrete variables, having a bijection with the set of natural numbers) rather than *continuous* (analogously to continuous functions). A tentative and indicative list of topics¹ that we intend to study in this semester is given below. Note that most of the thematic areas listed below, for example, combinatorics, graph theory, number theory, information theory, etc., are deep and vast subject areas on their own; interested students are encouraged to follow up on any area/s they might find interesting.

2 Topics

Here is the list of topics for the course. Most of these will be covered in varied depth depending on your preparedness and the availability of time. The topics may be covered in an order different from what is presented below.

1. **Sets:** • Relations • Functions or Mappings • Injections, Surjections, and Bijections • Equivalence classes • Finite and Infinite Sets • Countable and Uncountable sets
2. **Some Problem-Solving Strategies:** • Mathematical Induction • The Pigeonhole Principle • The Invariance Principle
3. **Mathematical Logic:** • Propositional Logic • First-Order Logic • Rules of Inference • Proof Methods and Strategy
4. **Number Theory:** • Divisibility • The Fundamental Theorem of Arithmetic • The Greatest Common Divisor • Congruences
5. **Combinatorics:** • Basics of Counting • The Binomial Theorem and the Multinomial Theorem • The Principle of Inclusion-Exclusion
6. **Growth of Functions and Asymptotic Notations:** • Big-Oh (O) & Big-Omega (Ω), Small-Oh (o) & Small-Omega (ω), and Theta (Θ) notations • Asymptotic complexity of algorithms
7. **Recurrence Relations:** • Generating Functions of Sequences • Calculating Coefficients of Generating Functions • Solving Recurrence Relations by Substitution and Generating Functions • The Method of Characteristic Roots • Solutions of Inhomogeneous Recurrence Relations
8. **Graph Theory:** • Graphs and Digraphs, Complement, Isomorphism, Connectedness and Reachability, Adjacency Matrix • Eulerian Paths and Circuits in Graphs and Digraphs • Hamiltonian Paths and Circuits in Graphs and Tournaments • Trees – Minimum Spanning Tree, Rooted Trees and Binary Trees • Planar Graphs – Euler's Formula • Independence Number and Clique Number • Statement of Four-Color Theorem
9. **Boolean Algebra:** • Operators • Laws of Boolean algebra • Boolean variables and functions
10. **Information Theory:** • Entropy, Conditional Entropy, Cross-Entropy.

¹1970's witnessed a lot of debate on the mathematics that computer scientists *must* know. Donald E Kunth taught a course on *Concrete Mathematics* at Stanford University for several years that culminated in his seminal work by the same name.

3 Learning Management System

We will be using Google Classroom as the learning management system for this course. You will automatically be added to the Google Classroom for this course via Ashoka LMS. All the course material, including lecture presentations, and assignments will be made available through the Google Classroom. In addition, we will be accepting student submissions only through Google Classroom links.

4 Class Schedule

We will meet at *AC-01-LT-207* during the scheduled class hours – *every Monday and Wednesday, from 4:40pm to 6:10pm*. Some classes will be held online while the rest will be physical. We will use Google Meet for online classes. The link will be shared before the class.

5 Consultation and Academic Support

The course staff (instructor and TAs) would be regularly available for consultation and academic support.

- **Offline Consultation:** The course staff would be available on email on a daily basis (almost on all days). Please contact using the email list cs1104-2-staff@ashoka.edu.in. *Emails to individual course staffs may be ignored.*
- **Face-to-face Consultation with the Instructor:** The instructor will hold an **Office Hours (OH)** once every week by appointment based on mutual convenience of the instructor and the students. The TAs will coordinate the schedule. The office hours may be physical or online depending on the presence of the instructor on the campus.
- **Face-to-face Consultation with the TAs:** Office hours with the TAs will be held on a need basis and based on the mutual convenience of the TAs and the students. Often TAs may call for OH to discuss evaluations of assignments and / or quizzes, if needed.

6 Teaching Assistants

Sl.#	Name	Email
1	Abhimanyu Timbadia	abhimanyu.timbadia_asp23@ashoka.edu.in
2	Shambhavi Kurup	shambhavi.kurup_asp23@ashoka.edu.in
3	Adwaiya Srivastav	adwaiya.srivastav_asp23@ashoka.edu.in
4	Bhumika Mittal	bhumika.mittal_ug24@ashoka.edu.in
5	Partha Pratim Das	partha.das@ashoka.edu.in

*Please do not call or WhatsApp the team members
Send mail to cs1104-2-staff@ashoka.edu.in when you need any help*

7 Textbooks and Readings

- Slides with links to online references
- *Discrete Mathematics and its Applications*, 7th Ed. by Kenneth H. Rosen (*Primary Textbook*)
- *Concrete Mathematics – A Foundation for Computer Science*, 2nd Ed. by Ronald L. Graham, Donald E. Knuth, and Oren Patashnik (*My favorite*)
- *Discrete Mathematics for Computer Scientists and Mathematicians* by Joe L. Mott, Abraham Kandel, and Theodore P. Baker.
- *Applied Combinatorics* by Fred Roberts and Barry Tesman.
- *Graph Theory with Applications to Engineering and Computer Science* by Narsingh Deo.
- *Introduction to Graph Theory* by Douglas B. West.

No book discusses all the topics. *So it is important to attend all the lectures by the instructor. You are also expected to carefully study the solved problems that will periodically be posted.*

8 Evaluation and Grading

The following is a tentative guideline for evaluations and the grading policy. It may undergo a changes.

1. **Assignments:** There will be biweekly (on an average) assignments – six in total – to solve mathematical problems and/or write mathematical proofs. All the assignments will
 - be combined to contribute **20%** to your final score.
 - not carry the same credits.
 - be released through the LMS.
 - be take-home with online submission through the LMS.
2. **Quizzes:** There will be three in-class quizzes that will require you to solve mathematical problems and/or write mathematical proofs. All the quizzes will
 - be combined to contribute **30%** to your final score.
 - carry the same credits.
 - be conducted physically in the classroom with online submission through the LMS.
3. **Mid-term Exam:** Mid-term Exam will
 - contribute **20%** to your final score.
 - be conducted physically in the classroom with physical submission.
4. **End-term Exam:** End-term Exam will
 - contribute **30%** to your final score.
 - be conducted physically in the classroom with physical submission.

The tentative calendar of evaluation events is given below. This may change in consultations with you.

Week #	Mode of Evaluation	Assign		Submission		# of Days	Evaluation Date
		Date	Day	Date	Day		
W02	Assignment 1	03-Feb-23	Fri	20-Feb-23	Mon	18	02-Mar-23
W04	Assignment 2	17-Feb-23	Fri	06-Mar-23	Mon	18	16-Mar-23
	Quiz 1	18-Feb-23	Sat				25-Feb-23
W06	Assignment 3	03-Mar-23	Fri	20-Mar-23	Mon	18	30-Mar-23
	Mid-Term	01-Mar-23	Wed				08-Mar-23
W09	Assignment 4	24-Mar-23	Fri	10-Apr-23	Mon	18	20-Apr-23
	Quiz 2	25-Mar-23	Sat				01-Apr-23
W11	Assignment 5	07-Apr-23	Fri	24-Apr-23	Mon	18	04-May-23
W13	Assignment 6	21-Apr-23	Fri	08-May-23	Mon	18	18-May-23
	Quiz 3	22-Apr-23	Sat				29-Apr-23
W16	End-Term	10-May-23	Wed				17-May-23

Score to Grade Conversion. The grading in the course will be relative. Final grades will be assigned in line of the *Indicative Percentage Band to Grade Conversion* as shown in Table 1. Depending on the Bell Curve, the letter grade boundaries will be adjusted at the time of final grading.

Final Score	Letter Grade	Final Score	Letter Grade
$x \leq 50$	F	$70 < x \leq 75$	B-
$50 < x \leq 53$	D-	$75 < x \leq 80$	B
$53 < x \leq 56$	D	$80 < x \leq 86$	B+
$56 < x \leq 59$	D+	$86 < x \leq 93$	A-
$59 < x \leq 62$	C-	$93 < x \leq 96$	A
$62 < x \leq 66$	C	$x > 96$	A+
$66 < x \leq 70$	C+		

Table 1: Numerical Score to Letter Grade Conversion Policy

Note: The symbol x denotes the aggregate numerical score accumulated – according to the policies outlines above – by you over the entirety of the course duration.

9 Submission Policies

We are aware of the fact that you're juggling multiple activities and the assigned deadlines may not always be favorable. In order to meet deadlines, it would be best for you to start on your assignments as soon as they are handed out. Starting working on an assignment on the day of the submission is the worst idea you could possibly come up with. Historically, this has resulted in scores that are below average performance. Starting your work late also creates conditions for plagiarism, which is something that you should definitely avoid – at all costs. You are expected to submit the assignments before the assigned deadline. We will follow the following policies:

1. **Mode of Submission:** All assignments must be submitted electronically through the Google Classroom for the course. *No email based submissions will be considered.*
2. **Format of Submission:** All assignments have to be properly formatted using the L^AT_EX typesetting system² and submitted as a single PDF named as `A<assignment #>_<your first name #>_<your Ashoka ID #>.pdf`.
3. **Late Submission:** Late submissions are possible.
 - An assignment is counted as late, as soon as the clock for the assignment submission rolls over.
 - For every extra day that you take to submit, the assignment will lose 20% of its value.
 - Once the assignment loses 100% of its value, it will not be graded.
4. **Extension for Submission:** Extensions may be granted only in case of genuine emergencies, for example, medical problems, family-related issues, etc. All such extensions will solely be at the instructor's discretion.
 - Every request for extension on a medical ground must be corroborated by written certificate of incapacitation or prescription of rest issued from the infirmary at Ashoka. No other medical certificate will be accepted.
 - No extension will be allowed for representing in sports or other events.
5. **Compensation for Quiz / Mid-term Exam:** Only one compensation quiz may be allowed in the entire duration of the course to compensate for one or more quiz and / or mid-term exam. That is, if you miss two or more quizzes and / or mid-term exam, you will be considered for one compensation quiz only. All such extensions will solely be at the instructor's discretion.
 - The compensation may be granted only in case of medical emergency.
 - Every request for compensation on a medical ground must be corroborated by written certificate of incapacitation or prescription of rest issued from the infirmary at Ashoka. No other medical certificate will be accepted.
 - No compensation will be allowed for representing in sports or other events.
6. **Compensation for End-term Exam:** No compensation for end-term exam may be provided unless expressly recommended by the Head of the Department and the Dean, Academic Affairs.

10 Cheating and Plagiarism

- For any assignment or exam, feel free to refer to the lectures or the primary reading material. Looking up or seeking help from every other source – including the internet, especially ChatGPT³, – will be considered instances of plagiarism.
- For most of the assignments, you will be allowed to discuss the problems with your peers in the class. However, any work that you submit should be completely your own, and should be done in an individual setting. One rule of thumb that you may follow is:

While discussing something with your peers, do not use any pen and paper (or laptop). That is, do not write down anything during the discussions. Allow yourself to take only mental notes, and at a later point in time, when you are in the solitude of your own room, work out the mental notes on paper.

²A popular system is Overleaf L^AT_EX

³TAs will check similarity with ChatGPT-generated solutions for every assignment / exam. So, ...

- We will have zero tolerance for cheating – be it an assignment or an exam. Any evidence of academic integrity violations or plagiarism will result in an F grade for the entire course. No exceptions will ever be made. In addition, you will be reported to the OAA for academic integrity violation.
- If you have any, however small, questions about what counts as plagiarism – and what does not – please contact the instructor. *But I didn't know < insert-the-thing-you-did > was also counted as plagiarism* will not be considered an acceptable excuse.