

21-301 Combinatorics, Fall 2020

This syllabus is subject to change.

Course: 21-301 Combinatorics, Fall 2020

Class info: MWF. 1:20-2:10pm. on Zoom (Link will be available on Piazza).

Instructors:

Alan Frieze

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Course website: math.cmu.edu/~seyedkah/combfall2020

Course description The purpose of this course is to introduce a few important tools in combinatorics. These tools have a wide range of spectacular applications in Mathematics and Computer Science. Most of the motivating problems we discuss here are about sets and graphs. The course is divided to two parts. Part one is taught by Kaave Hosseini and Part two by Alan Frieze. A rough outline of the course is as follows.

Part 1.

- Basic techniques (inclusion-exclusion, double counting, pigeon-hole)
- Extremal graph theory
- Cauchy Schwarz and 4-cycle counting
- Basic Probabilistic Combinatorics and Ramsey Theory
- Linear Algebraic techniques in Combinatorics

Part 2.

- Advanced Probabilistic combinatorics: Chernoff bound and Lovasz Local Lemma
- Elementary Poset theory
- Combinatorial Games
- Generating functions and Polya theory

Class format The lectures will be presented online over Zoom. Attendance is not mandatory but highly encouraged. The lectures will be recorded and their link will be uploaded on Piazza.

Zoom logistics During lectures:

- The zoom link to the class will be announced on Piazza. Please refrain from sharing this link with anyone else.
- Keep your microphone muted, except during asking a question. You can also ask questions using the chat feature.
- To ask a question, you can either use the “raise hand” feature of zoom and talk when prompted, or just wait for the suitable time and start speaking without prior notice.
- You may turn your video on or off, based on your personal preference. If we experience bandwidth problems, everyone will be asked to turn their videos off.
- There are no restrictions in using your real names. You may use an anonymous alias if you wish.
- Typically a few hours—until the video is uploaded to the Cloud—after each class, a link to the recorded lecture will be uploaded in the “Resources” section of Piazza.
- Students are not allowed to share the recording anywhere to protect the FERPA rights of all students in the classroom.

During office hours:

- You may attend the office hour at any time during the designated time window, however, please refrain from arriving late, since there might be other students already in line, or the discussions may take long.
- The office hours will not be recorded to give students more comfort in asking questions.

- Please keep track of the current participants in the session and ask questions in your own turn.
- Keep your mic muted, except during asking a question. You can also ask questions using the chat feature.
- To ask a question, you can either use the “raise hand” feature of zoom and talk when prompted, or just wait for the suitable time and start asking question without prior notice.
- You may turn your video on or off, based on your personal preference.

Prerequisites You should be comfortable with linear algebra, basics of discrete mathematics and graph theory, and discrete probability. More importantly, a high degree of mathematical maturity and ability to understand and write rigorous proofs is necessary.

Learning objectives

1. Obtain dexterity in spotting the need for and applying elementary combinatorial techniques such as induction, double counting, first moment method, etc.
2. Be able to calculate asymptotic estimates and handle error terms without having to do exact computations.
3. Develop intuition and working knowledge about various properties of generic sets and graphs, via probabilistic arguments.
4. Spotting abstract combinatorial objects and concepts in applications and successfully apply methods taught in the course.

How to succeed in class: Here are a few guidelines that will make your learning experience fun and effective.

- Read the lecture notes available on Piazza before the class to have a rough idea of material of the class.
- During the class stay active and ask questions, either using chat or voice. This course has a diverse material with students coming from diverse backgrounds as well. It’s always good to ask all the questions you have during the class.
- Spend several hours a week to solve the homework problems. It’s recommended to form groups to for each homework assignment and discuss problems with your groupmates.
- If you have a special circumstance that will make you miss the deadline for an assignment, ask for an extension. Reasonable requests are allowed during the semester.

- Try to solve as many problems as you can. You can find more problems in the books/material introduced in the resources section.
- Attend office hours. Actively ask questions. Even if you don't have a particular question in mind, you might just attend and listen to the discussion happening during the office hours.
- Be active on Piazza. Ask questions. Try to answer questions of your classmates.

Resources Lecture notes will be available on Piazza before class. The following items are highly recommended as supplemental resources.

1. Book: Extremal Combinatorics with applications in Computer Science, Stasys Jukna. Available at CMU online library.
2. Lecture notes: Techniques in Combinatorics, Tim Gowers. <https://gowers.files.wordpress.com/2014/11/techniques2014notes.pdf>
3. Book: Linear algebra methods in combinatorics, László Babai and Péter Frankl

Online platforms

Homework There will be a new homework assignment almost every week. Homework assignments can be solved individually, or in groups of 2 or 3 (you can form a different group for every assignment). However, every individual should write their own solution several hours after group discussions, and list their group members. It's highly encouraged to type your solutions in \LaTeX , however, clear and legible handwritten solutions are also accepted. *You should upload your homework to Gradescope before its due date.* Late homework submissions are not allowed. Typically each homework assignment consists of 5 problems, all with equal points. The 5th problem is a bonus problem. Meaning the full grade for the assignment is 40, however you can get up to 50 points. Also the grades carry over. So if you do poorly in a homework assignment you can make up for it by solving the bonus problem of prior/upcoming weeks.

- **Piazza:** We use Piazza platform as a discussion environment. Students are welcome to ask/answer questions.

The sign-up link is: piazza.com/cmu/fall2020/21301/home

If you have not already signed up, you can use the following sign-up link: piazza.com/cmu/fall2020/21301

- **Gradescope** Grade scope is used to grade homeworks and midterms.

Assessment Your assessment will be based on weekly homework and four midterms. **There will be no final exam.** Your raw grade is computed as follows.

1. 40% homework assignments. Since there will be about 10 Homework assignments, each weekly assignment is worth about 4.5%. (your lowest homework score will be dropped.)
2. 20% each midterm. (your lowest midterm grade will be dropped, and the other three each worth 20%)

Your letter grade will be computed as follows.

A	B	C	D
90	80	70	60

The final grade will not be curved negatively, but there is a possibility of positively curving the grades. (based on the overall statistics of final grades)

Example: 90 is an A and 89.9999 is a B.

Academic Integrity Students must follow CMU's Code of Academic Integrity: <https://www.cmu.edu/policies/student-and-student-life/academic-integrity.html>

Student Well-Being This semester is unlike any other. We are all under a lot of stress and uncertainty at this time. Attending Zoom classes all day can take its toll on our mental health. Make sure to move regularly, eat well, and reach out to your support system or me if you need to. We can all benefit from support in times of stress, and this semester is no exception.