

Syllabus: CSC 488/288 Fall 2021

This syllabus is subject to change.

Course: CSC 488/288: Analytic Methods in Computer Science

Instructor: Kaave Hosseini kaave.hosseini@gmail.com

Lecture: MW. 4:50-6:05pm Location: Dewey Room 2110D

Office hours: W. 2:00-3:15pm Location: Wegmans 2507

Course description In this course we introduce a number of tools with analytic flavor that have an impressive range of applications in computer science and discrete mathematics. Although the objects we are dealing with (such as graphs, sets, boolean functions, and various models of computation) are discrete in nature, it turns out that an analytic point of view—as opposed to a purely combinatorial one—provides a powerful lens to study these objects.

We start with elementary tools such as probabilistic concentration bounds and then move on to more advanced material such as spectral graph theory, discrete Fourier analysis, and pseudorandomness. Applications of these tools in areas such as algorithms, coding theory, complexity theory, discrete mathematics, and machine learning will be discussed.

Course material Here is a tentative list of topics.

- Probability concentration bounds: Markov, Chebychev, and Chernoff
- Spectral structure of graphs
 - Application: clustering algorithms
 - Expander graphs
 - Combinatorial and spectral expansion
 - Application: derandomizing algorithms
 - Application: expander codes

- Spectral structure of Boolean functions
 - Application: Social choice theory
 - Application: PAC learning via sampling
 - Application: PAC learning via membership queries
- Pseudorandomness
 - Approximate linear maps
 - Application: Linearity testing via the BLR test
 - Small bias spaces
 - Application: Constructing error correcting codes
 - Approximate polynomials

Objectives Obtain knowledge to model and solve various combinatorial and algorithmic problems that are amenable to an analytic approach.

Prerequisites Students are expected to have familiarity with undergraduate level discrete mathematics, graph theory, linear algebra, and probability. Students interested in theoretical computer science and/or discrete mathematics are welcome.

Resources We will be using a number of resources for this class, some of which are the following.

1. Techniques in Combinatorics, Tim Gowers. <https://gowers.files.wordpress.com/2014/11/techniques2014notes.pdf>
2. Analysis of Boolean Functions, Ryan O'Donnell. <https://arxiv.org/pdf/2105.10386.pdf>
3. Analysis of Boolean Functions, Tom Sanders. <https://people.maths.ox.ac.uk/~sanders/abf/notes.pdf>
4. Extremal Combinatorics with applications in Computer Science, Stasys Jukna.
5. Fourier analysis of Boolean functions, Shachar Lovett. <http://cseweb.ucsd.edu/~slovett/teaching/WI17-CSE291/>

Attendance Attendance is not required however strongly encouraged given that this is an advanced class with no main reference book.

Assessment Evaluation will be based on homework assignments. There will be an assignment roughly every other week. Students can solve each assignment in groups of two, however, each student should write down their final solution individually. Every student should submit their solutions to Piazza. Late assignments are not permitted unless in urgent situations.

Communication Announcements, homework assignments, discussion, etc will be posed on Piazza. Here is the sign-up link for the course: piazza.com/rochester/fall2021/csc488

Academic Integrity Students must follow UR's Code of Academic Integrity: <https://www.rochester.edu/college/honesty/policy/index.html>

Disability resources The University of Rochester respects and welcomes students of all backgrounds and abilities. In the event you encounter any barrier(s) to full participation in this course due to the impact of a disability, please contact the Office of Disability Resources. The access coordinators in the Office of Disability Resources can meet with you to discuss the barriers you are experiencing and explain the eligibility process for establishing academic accommodations. You can reach the Office of Disability Resources at: disability@rochester.edu; (585) 276-5075; Taylor Hall; www.rochester.edu/college/disability.