

## MATH888 Graduate Combinatorics II Spring 2023

**Lectures** Tuesdays and Thursdays 11am-12.15pm Allison Hall, West Room 206

**Instructor** Dr. Sebastian Cioabă, [cioaba@udel.edu](mailto:cioaba@udel.edu)

**Office Hours** Mondays and Wednesdays 11am-noon or by appointment in person in Ewing 506 or via Zoom.

**Textbook** There will be no official textbook, but I will use my lecture notes and books such as:

- N. Alon and J. Spencer, *The Probabilistic Method*, 4th edition, Wiley.
- S. Ball and S. Weiner, *An Introduction to Finite Geometry*, on the Google drive.
- A.E. Brouwer and W. Haemers, *Spectra of Graphs*, Springer 2012, available online.
- J.van Lint and R.M. Wilson, *A Course in Combinatorics* 2nd edition, Cambridge Univ. Press.

### Topics

We will go deeper into topics and methods used in combinatorics such as spectral graph theory, algebraic combinatorics, coding theory, extremal combinatorics, finite geometry, probabilistic methods, and topological methods.

### Course Description

The objectives of this course are studying and understanding combinatorics in deeper detail, learn some of the connections between combinatorics and other areas of mathematics such as algebra, linear algebra, probability, geometry and topology and some of the applications to computer science and coding theory.

- Eigenvalues and expanders (equitable partitions, interlacing, expander mixing lemma, expanders, Ramanujan graphs, random walks).
- Finite geometry, design theory and coding theory (Latin squares, finite projective and affine planes, strongly regular graphs, block designs, codes).
- The probabilistic method (basic method, Lovász local lemma, random graphs basics).
- Extremal combinatorics (LYM inequality, Kruskal-Katona theorem, Erdős-Ko-Rado theorem).
- Topological combinatorics (chromatic number of the Kneser graph, Brouwer fixed theorem).

Ideally, after taking this class and doing the required homework and exams, a student should have a solid knowledge of the fundamentals of combinatorics, be aware of some research highlights from recent years and should be able to attend a conference in discrete mathematics and understand the basic ideas and methods in most of the talks. The lectures are important for your understanding of the material and even though attendance is not mandatory, I encourage you to attend every class.

### Grading

- **Homework** (55% of the final grade). I will assign homework every week or so. The homework questions will be non-trivial and you will likely have to work hard to solve them, but you are encouraged to discuss them with me during office hours. For the homework problems, you can discuss it with your colleagues, but there should be no collaboration on writing up the solutions.
- **Exams** (45% of the final grade). There will be three take-home exams that will take place during the weeks of March 15, April 12 and May 10. For the take-home exams, no joint work between the students is allowed.
- Your letter grade for this course will be determined from the following scheme:  
A: 90-100, A-: 85-90, B+:80-85, B: 75-80, B-: 70-75, C+: 65-70, C: 60-65, C-:55-60, D: 50-55, F: 0-50