MATH 432 COMBINATORICS
SPRING 2022 SYLLABUS

GRETA PANOVA

Location and meeting times: MWF 12-12:50, CPA 256 (in person, offline).

Instructor Office Hours: M 3:30-5 (in KAP), F 2:30-3:30 (in KAP), by appointment (over zoom), or via slack.

Teaching Assistant: TBA

Course description. This course is a broad introduction to *Combinatorics*, surveying a variety of topics and methods. We introduce some basic counting techniques (e.g. Pigeonhole principle, independence) and elementary proof techniques (e.g. mathematical induction and counting in two different ways). We apply these to basic enumeration of subsets, arrangements, and other similar structures with restrictions. We will also study generating functions and use them to enumerate more complex structures and solve recurrence relations. We study the basics of graph theory (e.g. colorings, matchings) and algorithms on graphs. Last, but not least, we will discuss basic computational complexity theory.

Learning Objectives. Our goal would be to develop problem solving skills and mathematical maturity by studying advanced counting techniques. By the end of the course, students should be able to write proofs, analyze basic enumeration questions and combinatorial algorithms, and being able to solve some problems concerning simple finite structures, somewhat similar in spirit to the "logic/quantitative puzzles" typical for software/finance industry interviews.

Mode of instruction. Lectures will take place in person in class at the scheduled times. Detailed schedule, material covered, pictures of the blackboard, notes and other materials will be uploaded on blackboard regularly. Course announcements will be posted on blackboard and emailed. Slack will be used for discussions.

Prerequisites: MATH 225 or MATH 226 or MATH 227.

Course text and sources: Homework, exam solutions, and supplementary notes will be available in Blackboard.

Textbook:

Miklos Bona, *A Walk Through Combinatorics*, 4th edition.

Additional resources (freely available online):

Richard Stanley "Enumerative Combinatorics Volume 1".

Loren Larson "Problem-solving through problems".

Office KAP 424C, e-mail: gpanova@usc.edu, https://sites.google.com/usc.edu/gpanova. Zoom: 573 271 7847.

Grading. Students are expected to complete weekly **problem sets**, whose goal is to reinforce and expand the topics covered in class in order to deepen the understanding, practice, learn. There will be 12 problem sets, each worth the same amount of points. The two lowest homework grades (including zeros for missing homeworks) will be dropped at the end. Homeworks will be generally **due on Wednesdays** uploaded on blackboard. Late assignments will be penalized by 20% per day.

There will be two in-class midterm exams, on February 16 and March 30, and a final exam on Friday, May 6, 2-4pm.

Score distribution

Assignment	% **Final Grade**
Homeworks (10 best out of 12)	25%
Midterm I	20%
Midterm II	20%
Final Exam	35%

Course Letter Grades: will be based on the total scores and determined "on a curve".

Bonus problems will be given regularly in homeworks. They will be more challenging, in the style of math olympiads/Putnam competition or brain teasers, and will not be counted towards the grade.

Preliminary Course Schedule of Topics:

Week/Date	Topic
Week 1, 01/10	Methods of proof: contradiction, pigeonhole principle, induction
Week 2, 01/17	Elementary counting
Week 3, 01/24	Binomial theorem and identities
Week 4, 01/31	Partitions and permutations
Week 5, 02/07	Sieve methods, inclusion-exclusion
Week 6, 02/14	Review and midterm I
Week 7, 02/21	Generating functions
Week 8, 02/28	Introduction to graph theory
Week 9, 03/07	Trees, the matrix-tree theorem
Week 10, 03/14	Spring break!!! :-)
Week 11, 03/21	Colorings and matchings
Week 12, 03/28	Review and midterm II
Week 13, 04/04	Planar graphs, Ramsey theory
Week 14, 04/11	Probabilistic methods
Week 15, 04/18	Algorithms, computational complexity
Week 16, 04/25	Problem solving as material review
Week 17, the end	Final exam on May 6