UNSW SYDNEY

Faculty of Science
School of Mathematics & Statistics

Course Outline

MATH5505

Combinatorics

Term 3, 2020

SCHOOL OF MATHEMATICS AND STATISTICS
UNSW Sydney

MATH5505 Combinatorics Term 3 2020

Lecturer: Dr Anita Liebenau
Email: a.liebenau@unsw.edu.au

MATH5505 is a 6 UOC level V course, suitable for Honours students or coursework Masters students, or for undergraduates with suitably high marks in relevant mathematics subjects, by permission of the lecturer. There are no official prerequisites and no exclusions.

This course will be **100% online**. The Moodle page will be the central point of information and contact.

Lectures:
There will be two hours of lectures per week, in weeks 1–3, 5 and 7–10. In week 4, there will be no Monday lecture (public holiday), and in week 6 there are no lectures.

- Monday 11:00 – 12:00, weeks 1–3, 5 and 7–10
- Wednesday 11:00 – 12:00, weeks 1–5 and 7–10

In total there will be 17 hours designated as lectures. In some weeks, we may use the tutorial time (see below) as a lecture. This will be adjusted throughout the term as needed and communicated via Moodle.

The lectures will be live and I encourage you to attend them. The (online) location will be posted to Moodle.

Tutorials:
Tutorials are **essential** to this course and I strongly recommend to attend them live. Combinatorics is about solving problems, and the tutorials are arranged so that you learn how to solve hard problems with guidance.

There will be a 2-hour block of tutorials every week. There will be no tutorial in week 6.

- Thursday 9:00 – 11:00, weeks 1–5 and 7–10

At the beginning of the tutorial you will be given a problem sheet with questions that help you understand the course material of the same week. You will be split in groups of size three or four and work on solutions in small teams.

There will be **no sample solutions** to tutorial sheets, though guidance will be given during tutorials on how to find solutions.

Consultation:
Monday 1-2pm via Zoom, location to be posted to Moodle.

Please feel free to contact me any time via email or using the Moodle forum to pose questions.

Peer support:
I encourage you to use the Moodle discussion forum actively for posting your questions. Your fellow students may have the same question and will appreciate you stepping forward. Please help each other throughout the course either in the discussion forum or through study groups.

There will be three zoom rooms (to be updated on Moodle) where you can meet without me at any time to discuss the course content and possible questions with your peers. Think of them like empty seminar rooms where you meet with your friends to understand the course material. Of course, you can meet through other channels that suit you more.

Course description

Combinatorics is a wide field with many facets. Broadly speaking, combinatorics is the study of finite or discrete objects, like graphs, integers, set systems, integer-valued matrices, etc. Problems are typically easy to state without using much theoretical background. Solutions, however, are often quite hard to find. About a century ago, solutions used to be somewhat ad-hoc. By now, the field has matured and produced quite beautiful theories. Solutions to problems now use methods from linear algebra, from probability theory, and from graph theory, to name a few.

The course aims to cover various aspects of modern combinatorics, including the combinatorics of set systems, a little bit of graph theory that is not covered in MATH5425 Graph Theory, some Ramsey theory, the probabilistic method, and some discrete geometry. A focus will lie on solving problems by applying the methods learned in lectures. The course thus fosters the ability of students to create their own mathematical proofs.

Detailed course outline
We plan to cover the following topics. The indicated weeks are approximate and may change throughout the term.

Week 1	Chains, antichains and shadows
Week 2	Chains, antichains and shadows
Week 3	Intersecting set systems and linear-algebra method
Week 4	Intersecting set systems and linear-algebra method
Week 5	Intersecting set systems and linear-algebra method
Week 6	(break: no MATH5505 lectures or tutorials)
Week 7	Extremal graph theory
Week 8	Ramsey Theory
Week 9	Probabilistic Method
Week 10	The Happy Ending problem; and Consolidation

Relation to other mathematics courses
Combinatorics is a subset of discrete mathematics. If you have taken a discrete mathematics course then you will have probably seen some graph theory and some basic probability theory.

Probability theory is an extremely useful part of mathematics and statistics, used in many areas.

In MATH5505 no prior knowledge of graph theory or probability theory is assumed, though familiarity with the basic concepts as taught, for example, in MATH1081 Discrete Mathematics is an advantage. The basic discrete probability theory required for this course will be introduced when it is needed.

Additionally, we will assume that the students are familiar with the following elementary fact from linear algebra: A basis in a vector space of dimension n has n elements.

The course aims to be disjoint from the Honours Course MATH5425 Graph Theory (taught in T3 2019 and T1 2021), though some repetition will be unavoidable. No knowledge from MATH5425 will be assumed.

Course learning outcomes

Students taking this course will:

- come to understand many concepts and definitions used in combinatorics,
- master various combinatorial and probabilistic techniques,
- develop their ability to manipulate and apply these concepts and techniques to solve simple and complex problems in combinatorics.

These outcomes particularly contribute to the students' research, inquiry and analytical thinking abilities; and strengthen the capacity for analytical and critical thinking and for creative problem solving.

Teaching strategies used

New concepts and techniques are first introduced and demonstrated in lectures, then students master these concepts and techniques by applying them to problem sheet questions and assessment tasks. In lectures, students will be expected to think, as well as listen, and will have the opportunity to test their understanding by answering questions posed by the lecturer. In tutorials, solutions will be worked on in small teams. Solution finding will be assisted by the tutor.

Rationale: We believe that effective learning is best supported when students are actively engaged with the new mathematical concepts and techniques, for example by working through the new material independently, asking questions during lectures and making a serious attempt to solve the problem sheet questions together with their peers during the tutorials.

To ensure effective learning, you should participate actively in all classes, whenever possible. Asking questions is particularly encouraged — in lectures, in tutorials, in the Moodle forum, etc.

Assessment

The assessment components for this course are as follows.

Assessment task	date released	due date	weight
Assignment 1	1st lecture, Week 1	1st lecture, Week 3	15%
Assignment 2	1st lecture, Week 5	1st lecture, Week 8	25%
Final exam			60%

Assessment criteria: In the assignments and the exam, marks will be awarded for correct working, logical setting out, appropriate explanations, clear notation and presentation, as well as for the final answer. The aim of this is to develop students' ability to present their mathematics in a professional way.

Assessment rationale: The assignments will provide feedback on students' progress and may introduce new concepts not covered in lectures.

Further assessment information

Assignments may be handwritten or prepared using the mathematical typesetting language LaTeX.

Students may discuss solutions to assignment questions with other students currently taking the course, *provided* that they write up their solution independently (and not simply copy from each other) and acknowledge help that they have received from fellow students or from books (giving a reference).

Information on submission will be provided on Moodle soon.

Examination

The exam is likely to be an **Open-book exam.** That means that, in theory, you may use any course material during the exam. A word of **caution**: There won't be enough time to read and understand lecture material during the exam. You will need to gain a thorough understanding of the material during the term. Revising lecture material on the same day of the lecture and working actively on the problem sheets during the tutorials are crucial.

Any theorems or facts from the lecture notes need to be stated clearly.

Further information about the exam will be given on Moodle towards the end of the course.

Additional resources

Lecture notes containing definitions and theorem statements will be made available via Moodle. Proofs are provided during lectures and students are encouraged to write them down line by line.

Some miscellaneous handouts may also be made available at various points of the course.

This course will initially follow a similar course by Alex Scott (University of Oxford), which, in turn, is based on the book *Combinatorics* by Béla Bollobás and on notes from two courses by Imre Leader.

Other material will be drawn from

- N. Alon and J. Spencer, *The Probabilistic Method* (Wiley 2000).
- A. Suk, *On the Erdos-Szekeres convex polygon problem* Journal of the American Mathematical Society 30.4 (2017): 1047-1053.

There are many books online and in the UNSW Library that may serve as additional reading material. None of these additional resources are required.

Course evaluation and development

The School of Mathematics and Statistics evaluates each course each time it is run. Feedback on the course is gathered, using among other means, UNSW's myExperience surveys. Student feedback is taken seriously and continual improvements are made to the course based in part on such feedback.

Administrative matters

- The School of Mathematics and Statistics has policies regarding attendance, additional assessment, special consideration in the event of illness and misadventure, and so on. *We assume that you are familiar with these policies, so please familiarise yourself with them!* See http://www.maths.unsw.edu.au/currentstudents/assessment-policies and https://student.unsw.edu.au/policy
- You should also know what plagiarism is and be aware of UNSW's plagiarism policy. See https://student.unsw.edu.au/plagiarism/ and https://student.unsw.edu.au/conduct
- Find support and resources related to your wellbeing, health and safety here: https://student.unsw.edu.au/wellbeing
- UNSW has a Student Equity and Disabilities Unit http://www.studentequity.unsw.edu.au