Course guide
34955 - COMB - Combinatorics

Last modified: 23/06/2025

Unit in charge: School of Mathematics and Statistics
Teaching unit: 749 - MAT - Department of Mathematics.

Degree: MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Optional subject).

Academic year: 2025 **ECTS Credits:** 7.5 **Languages:** English

LECTURER

Coordinating lecturer: JUAN JOSÉ RUE PERNA

Others:

PRIOR SKILLS

Basic calculus and linear algebra. Notions of probability.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. RESEARCH. Read and understand advanced mathematical papers. Use mathematical research techniques to produce and transmit new results.
2. CALCULUS. Obtain (exact or approximate) solutions for these models with the available resources, including computational means.
3. CRITICAL ASSESSMENT. Discuss the validity, scope and relevance of these solutions; present results and defend conclusions.
MAMME-CE2. MODELLING. Formulate, analyse and validate mathematical models of practical problems by using the appropriate mathematical tools.

Transversal:
4. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.
5. EFFICIENT ORAL AND WRITTEN COMMUNICATION. Communicating verbally and in writing about learning outcomes, thought-building and decision-making. Taking part in debates about issues related to the own field of specialization.
6. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.
7. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.
8. EFFECTIVE USE OF INFORMATION RESOURCES. Managing the acquisition, structure, analysis and display of information from the own field of specialization. Taking a critical stance with regard to the results obtained.

TEACHING METHODOLOGY

There will be a lecture each week, followed by a problem session.

LEARNING OBJECTIVES OF THE SUBJECT

To use algebraic, probabilistic and analytic methods for studying combinatorial structures. The main topics of study are: partially ordered sets, extremal set theory,finite geometries, Ramsey theory and enumerative combinatorics.

STUDY LOAD

Type	Hours	Percentage
Hours large group	60,0	32.00
Self study	127,5	68.00

Total learning time: 187.5 h

CONTENTS

Partially ordered sets and extremal set theory

Description:
Sperner's theorem. LYM inequalities. Bollobás's theorem. Erdos-Ko-Rado Theorem. Dilworth's theorem. Applications of Dilworth Theorem. Lattices and distributive lattices. The 4 functions theorem and applications

Full-or-part-time: 24h 40m
Practical classes: 4h
Laboratory classes: 4h
Self study : 16h 40m

Ramsey theory

Description:
Theorems of Ramsey and Hales-Jewett. Theorems of Schur, Van der Waerden and Rado.

Full-or-part-time: 31h 40m
Theory classes: 5h
Laboratory classes: 5h
Self study : 21h 40m

Probabilistic methods in combinatorics

Description:
First and second moment. Lovász Local Lemma and entropy methods. Applications: Permanents, transversals, hypergraph coloring. Monotone properties and threshold functions.

Full-or-part-time: 18h 30m
Theory classes: 3h
Laboratory classes: 3h
Self study : 12h 30m

Linear algebra methods in combinatorics

Description:
The Combinatorial Nullstellensatz. The polynomial method. Fisher's theorem. Applications

Full-or-part-time: 18h 30m
Theory classes: 3h
Laboratory classes: 3h
Self study : 12h 30m

GRADING SYSTEM

Continous evaluation will be based on the weekly solution of exercises. There will be also a final examination. The grading will be based on the continous evaluation during the course (60%) and the final exam (40%).

BIBLIOGRAPHY

Basic:

- Alon, Noga; Spencer, Joel H.; Erdös, Paul. The Probabilistic method. 3rd ed. New York: Wiley, 2008. ISBN 0471535885.
- Bollobás, Béla; Andrew Thomason (eds.). Combinatorics, geometry, and probability : a tribute to Paul Erdos. Cambridge: Cambridge University Press, 1997. ISBN 0521584728.
- Lint, Jacobus Hendricus van; Wilson, R. M. A Course in combinatorics. 2nd ed. Cambridge: Cambridge University Press, 2001. ISBN 0521803403.
- Flajolet, P.; Sedgewick, R. Analytic combinatorics [on line]. Cambridge: Cambridge University Press, 2009 [Consultation: 07/07/2023]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=412737. ISBN 9780521898065.
- Graham, Ronald L.; Rotschild, B.; Spencer, J. Ramsey theory. 2nd ed. New York: John Wiley & Sons, 1990. ISBN 0471500461.
- Anderson, Ian. Combinatorics of finite sets. Mineola: Dover, 2002. ISBN 0486422577.
- Lovász, László. Combinatorial problems and exercices. 2nd ed. Amsterdam: North-Holland, 1993. ISBN 044481504X.
- Oxley, J. G. Matroid theory [on line]. 2nd ed. Oxford: Oxford University Press, 2011 [Consultation: 13/12/2022]. Available on: https://academic-oup-com.recursos.biblioteca.upc.edu/book/34846?searchresult=1. ISBN 9780199603398.
- Jukna, Stasys. Extremal combinatorics. 2011. Springer, 2011. ISBN 9783642173639.