Course guides
34955 - COMB - Combinatorics

Last modified: 31/05/2020

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: 2020 **ECTS Credits:** 7.5 **Languages:** English

LECTURER

Coordinating lecturer: ORIOL SERRA ALBO

Others: Segon quadrimestre:
MARCOS NOY SERRANO - A
JUAN JOSÉ RUE PERNA - A
ORIOL SERRA ALBO - A

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.

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, matroids, 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

Description:
Sperner's theorem. LYM inequalities. Bollobás's theorem. Dilworth's theorem

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

Extremal set theory

Description:
Theorems of Baranyai, Erdos-de Bruijn and Erdos-Ko-Rado

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

Linear algebra methods in combinatorics

Description:
The polynomial method and applications. Fisher's theorem. Equiangular lines, sets with few differences

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

Finite geometries

Description:
q-anologs of extremal problems. Segre's theorem. Blocking sets, ovals and hyperovals.

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

Matroids

Description:
Axioms. Transversal matroids. Greedy algorithms. The Tutte polynomial

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

Probabilistic methods in combinatorics

Description:
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

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

Enumerative combinatorics

Description:
Symbolic and analytic methods. Symmetries and Pólya theory.

Full-or-part-time: 32h 30m
Theory classes: 5h
Laboratory classes: 5h
Self study : 22h 30m

GRADING SYSTEM

Grading will be based on the solution of exercises. Eventually there will a final examination.

BIBLIOGRAPHY

Basic:
- Jukna, Stasys. Extremal Combinatorics. 2011. Springer, 2011. ISBN 978-3-642-17363-9.
- 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. 2nd ed. Oxford: Oxford University Press, 2011. ISBN 9780199603398.
- Lint, Jacobus Hendricus van; Wilson, R. M. A Course in combinatorics. 2nd ed. Cambridge: Cambridge University Press, 2001. ISBN 0521803403.
- 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.
- Flajolet P.; Sedgewick R. Analytic combinatorics [on line]. Cambridge: Cambridge University Press, 2009 [Consultation: 19/05/2020]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=412737. ISBN 9780521898065.
- Graham, Ronald L.; Rotschild, B.; Spencer, J. Ramsey theory. 2nd ed. New York: John Wiley & Sons, 1990. ISBN 0471500461.