## Course guides
### 34955 - COMB - Combinatorics

<table>
<thead>
<tr>
<th>Unit in charge:</th>
<th>School of Mathematics and Statistics</th>
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<tbody>
<tr>
<td>Teaching unit:</td>
<td>749 - MAT - Department of Mathematics.</td>
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<tr>
<td>Degree:</td>
<td>MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Optional subject).</td>
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<td>Academic year:</td>
<td>2020</td>
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<tr>
<td>ECTS Credits:</td>
<td>7.5</td>
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<td>Languages:</td>
<td>English</td>
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### 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

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Hours large group</td>
<td>60.0</td>
<td>32.00</td>
</tr>
<tr>
<td>Self study</td>
<td>127.5</td>
<td>68.00</td>
</tr>
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</table>

**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:**

**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: