34955 - COMB - Combinatorics

**Coordinating unit:** 200 - FME - School of Mathematics and Statistics

**Teaching unit:** 749 - MAT - Department of Mathematics

**Academic year:** 2019

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

**ECTS credits:** 7,5  
**Teaching languages:** English

### Teaching staff

**Coordinator:** ORIOL SERRA ALBO

**Others:** Segon quadrimestre:
- 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. **EFFICIENT 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:
34955 - COMB - Combinatorics

partially ordered sets, extremal set theory, finite geometries, matroids, Ramsey theory and enumerative combinatorics.

<table>
<thead>
<tr>
<th>Study load</th>
<th>Hours large group:</th>
<th>60h</th>
<th>32.00%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total learning</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>time: 187h 30m</td>
<td>Self study:</td>
<td>127h 30m</td>
<td>68.00%</td>
</tr>
</tbody>
</table>
**Content**

<table>
<thead>
<tr>
<th>Section</th>
<th>Learning time</th>
<th>Theory classes</th>
<th>Laboratory classes</th>
<th>Self study</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Partially ordered sets</strong></td>
<td>24h 40m</td>
<td>4h</td>
<td>4h</td>
<td>16h 40m</td>
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<tr>
<td><strong>Description:</strong></td>
<td></td>
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<tr>
<td>Sperner's theorem. LYM inequalities. Bollobás's theorem. Dilworth's theorem</td>
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| **Extremal set theory**              | 24h 40m       | 4h             | 4h                 | 16h 40m    |
| **Description:**                     |               |                |                    |            |
| Theorems of Baranyai, Erdos-de Bruijn and Erdos-Ko-Rado |               |                |                    |            |

| **Linear algebra methods in combinatorics** | 18h 30m | 3h | 3h | 12h 30m |
| **Description:**                       |         |    |    |         |
| The polynomial method and applications. Fisher's theorem. Equiangular lines, sets with few differences |         |    |    |         |

| **Finite geometries**                | 18h 30m   | 3h  | 3h  | 12h 30m |
| **Description:**                     |           |    |    |         |
**Matroids**

**Learning time:** 18h 30m  
Theory classes: 3h  
Laboratory classes: 3h  
Self study: 12h 30m

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

| **Probabilistic methods in combinatorics** | **Learning time:** 18h 30m  
Theory classes: 3h  
Laboratory classes: 3h  
Self study: 12h 30m |
|------------------------------------------|------------------------------------------------------------------|
| **Description:**  
Permanents, transversals, hypergraph coloring. Monotone properties and threshold functions |

| **Ramsey theory** | **Learning time:** 31h 40m  
Theory classes: 5h  
Laboratory classes: 5h  
Self study: 21h 40m |
|-------------------|-----------------------------------------------------------------|
| **Description:**  
Theorems of Ramsey and Hales-Jewett. Theorems of Schur, Van der Waerden and Rado. |

| **Enumerative combinatorics** | **Learning time:** 32h 30m  
Theory classes: 5h  
Laboratory classes: 5h  
Self study: 22h 30m |
|-----------------------------|-----------------------------------------------------------------|
| **Description:**  
Symbolic and analytic methods. Symmetries and Pólya theory. |

**Qualification system**

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

**Basic:**


