34957 - GT - Graph Theory

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: Primer quadrimestre:
ANNALLO SANCHEZ - A
MARCOS NOY SERRANO - A
ORIOL SERRA ALBO - A

Prior skills

Elementary Calculus and Linear Algebra; basic notions and abilities in combinatorics and 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

Sessions of presentation of material alternate with sessions with student presentations of problems and specific topics. The active participation of students is a requirement for the evaluation of the course.

Learning objectives of the subject
Extremal graph theory
Application of spectral techniques to the study of graphs.
Application of the probabilisitic method.
Properties of almost all graphs.
Properties of Cayley and vertex symmetric graphs.
Graphs on surfaces.
Minors.

Study load

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

<table>
<thead>
<tr>
<th>Topic</th>
<th>Learning time:</th>
<th>Theory classes:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spectral techniques in Graph Theory</strong></td>
<td>12h</td>
<td>12h</td>
</tr>
<tr>
<td><strong>Description:</strong></td>
<td></td>
<td></td>
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<tr>
<td><strong>Specific objectives:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Symmetries in graphs</strong></td>
<td>1h</td>
<td>1h</td>
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<tr>
<td><strong>Description:</strong></td>
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<tr>
<td>Vertex symmetric and Edge symmetric graphs. Cayley graphs. Highly symmetric graphs</td>
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<tr>
<td><strong>Specific objectives:</strong></td>
<td></td>
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<tr>
<td><strong>Minors and treewidth</strong></td>
<td>11h</td>
<td>11h</td>
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<tr>
<td><strong>Description:</strong></td>
<td></td>
<td></td>
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<tr>
<td><strong>Specific objectives:</strong></td>
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<tr>
<td>Classes defined by forbidden minors. Serie-Parallel graphs. k-trees and tree width.</td>
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<tr>
<td><strong>Graphs on surfaces</strong></td>
<td>4h</td>
<td>4h</td>
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<tr>
<td><strong>Description:</strong></td>
<td></td>
<td></td>
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<tr>
<td><strong>Specific objectives:</strong></td>
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<tr>
<td>Euler formula. Planar separator theorem</td>
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## Graph homomorphisms

**Description:**
Graph homomorphisms. Retracts and Cores. The homomorphism order. Antichains.

**Specific objectives:**
Homomorphisms and colorings. Fractional and circular chromatic numbers.

**Learning time:** 6h
- Theory classes: 6h

## Random graphs

**Description:**

**Specific objectives:**
Graphs with large girth and large chromatic number. Expansion properties of random graphs. Threshold for connectivity. The Poisson paradigm.

**Learning time:** 12h
- Theory classes: 12h

## Extremal Graph Theory

**Description:**

**Specific objectives:**
Counting Lemma and Removal Lemma. Applications of Szemerédi regularity Lemma.

**Learning time:** 12h
- Theory classes: 12h

## Qualification system

The evaluation of the course is based on the weekly work on problems proposed in the presentation sessions. There will be a final comprehensive exam based on the problem sessions during the course.

## Regulations for carrying out activities

The active participation in the course is a requirement for the evaluation of the final exam.
Bibliography

Basic:


Alon, Noga; Spencer Joel. The Probabilistic Method. 2016. Wiley,

Complementary:
