200211 - AF - Functional Analysis

Coordinating unit: 200 - FME - School of Mathematics and Statistics
Teaching unit: 749 - MAT - Department of Mathematics
Academic year: 2019
Degree: BACHELOR'S DEGREE IN MATHEMATICS (Syllabus 2009). (Teaching unit Optional)
ECTS credits: 6
Teaching languages: Catalan

Teaching staff
Coordinator: JUAN DE LA CRUZ DE SOLÀ-MORALES RUBIÓ
Others: Segon quadrimestre:
JUAN DE LA CRUZ DE SOLÀ-MORALES RUBIÓ - M-A
IÑIGO URTIAGA ERNETA - M-A

Degree competences to which the subject contributes

Specific:
8. Ability to solve problems from academic, technical, financial and social fields through mathematical methods.
9. CE-4. Have the ability to use computational tools as an aid to mathematical processes.
10. CE-3. Have the knowledge of specific programming languages and software.
11. CE-2. Solve problems in Mathematics, through basic calculation skills, taking in account tools availability and the constraints of time and resources.
12. CE-1. Propose, analyze, validate and interpret simple models of real situations, using the mathematical tools most appropriate to the goals to be achieved.

Generical:
3. CG-6 Detect deficiencies in their own knowledge and pass them through critical reflection and choice of the best action to extend this knowledge.
4. CG-4. Translate into mathematical terms problems stated in non-mathematical language, and take advantage of this translation to solve them.
5. CG-3. Have the ability to define new mathematical objects in terms of others already know and ability to use these objects in different contexts.
6. CG-2. Construct rigorous proofs of some classical theorems in a variety of fields of Mathematics.
7. CG-1. Show knowledge and proficiency in the use of mathematical language.

13. CB-4. Have the ability to communicate their conclusions, and the knowledge and rationale underpinning these to specialist and non-specialist audiences clearly and unambiguously.
14. To have developed those learning skills necessary to undertake further interdisciplinary studies with a high degree of autonomy in scientific disciplines in which Mathematics have a significant role.

Transversal:
1. 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.
2. 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.
200211 - AF - Functional Analysis

### Teaching methodology

Theory: the classes will consist of presentations by the professor of definitions, statements, demonstrations and examples. Emphasis on relationships between concepts apparently different for the student will be made.

Problems: Presentation of solutions to a collection previously proposed to the student. Also, resolution of some problems by the students themselves.

Among the objectives of the course, more importance will be given to problem solving and to the ability to relate with other areas of mathematics than the mere acquisition of theoretical knowledge.

### Learning objectives of the subject

section not available

### Study load

<table>
<thead>
<tr>
<th>Total learning time: 150h</th>
<th>Hours large group:</th>
<th>30h</th>
<th>20.00%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hours medium group:</td>
<td>0h</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td>Hours small group:</td>
<td>30h</td>
<td>20.00%</td>
</tr>
<tr>
<td></td>
<td>Guided activities:</td>
<td>0h</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td>Self study:</td>
<td>90h</td>
<td>60.00%</td>
</tr>
</tbody>
</table>
## Content

### Banach Spaces

**Learning time:** 30h  
- Theory classes: 6h  
- Laboratory classes: 6h  
- Self study: 18h

**Description:**  
- Banach spaces  
- Examples  
- Linear operators and norm  
- Fundamental theorems on linear bounded operators (open mapping, closed graph, uniform boundedness)

### Hilbert Spaces

**Learning time:** 45h  
- Theory classes: 9h  
- Laboratory classes: 9h  
- Self study: 27h

**Description:**  
- Scalar product  
- Projections  
- Representation theorems: Riesz-Frechet, Lax-Milgram  
- Adjoints in Hilbert spaces  
- Orthonormal bases

### Applications

**Learning time:** 45h  
- Theory classes: 9h  
- Laboratory classes: 9h  
- Self study: 27h

**Description:**  
- Motivation; boundary value problems in dimension one.  
- Sobolev spaces  
- Weak/classical solutions in dimensión one and in n dimensions  
- Existence/uniqueness and regularity issues  
- Laplace and heat equations  
- Introduction to nonlinear equations
There will be a partial exam, that will determine 35% of the final mark, and a final exam with 50%. The remaining 15% is evaluated from the assignments and expositions in class. The final mark, obtained with these proportions, could be increased, according to the development of the course.

**Bibliography**

**Basic:**


Rakotoson, Jean-Emile ; Rakotoson, Jean-Michel. Analyse fonctionnelle appliquée aux équations aux dérivées partielles. 1999.

**Complementary:**


### Compact operators

**Description:**
- Properties
- Spectrum
- Fredholm alternative
- Self-adjoint compact operators

**Learning time:** 30h
- Theory classes: 6h
- Laboratory classes: 6h
- Self study : 18h