Course guide
34961 - QQMDS - Quantitative and Qualitative Methods in Dynamical Systems

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).
(Optinal subject).
Academic year: 2023 ECTS Credits: 7.5 Languages: English

LECTURER
Coordinating lecturer: PAU MARTIN DE LA TORRE
Others:
Primer quadrimestre: INMACULADA CONCEPCION BALDOMA BARRACA - A
PAU MARTIN DE LA TORRE - A

PRIOR SKILLS
Good knowledge of calculus, algebra and differential equations. It is strongly recommended a good understanding of the basic theory of ordinary differential equations as well as a basic knowledge of dynamical systems from a local point of view.

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. MODELLING. Formulate, analyse and validate mathematical models of practical problems by using the appropriate mathematical tools.
3. CALCULUS. Obtain (exact or approximate) solutions for these models with the available resources, including computational means.
4. CRITICAL ASSESSMENT. Discuss the validity, scope and relevance of these solutions; present results and defend conclusions.

Transversal:
5. 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.
6. 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.
7. 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.
8. 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.
9. 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

We do not distinguish theoretical and practical classes. Some results about modern theory in Dynamical systems are presented in class. The main idea is to give basic knowledge and useful tools in the study of a dynamical system from both quantitative and qualitative points of view. We will stress the relation between different kind of systems and we will mainly focus in the use of perturvaties techniques to study a dynamical system globally.

LEARNING OBJECTIVES OF THE SUBJECT

STUDY LOAD

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
</tr>
</thead>
<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>
</tbody>
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Total learning time: 187.5 h

CONTENTS

Invariant objects in Dynamical Systems

Description:
Continuous and discrete Dynamical Systems.
Poincaré map.
Local behaviour of hyperbolic invariant objects. Conjugation.
Invariant manifolds.

Full-or-part-time: 10h
Theory classes: 10h

Normal forms

Description:
Poincaré-Dulac normal forms. Convergence: Poincaré and Siegel domains.

Full-or-part-time: 10h
Theory classes: 10h

Perturbation theory in Dynamical Systems

Description:

Full-or-part-time: 15h
Theory classes: 15h
<table>
<thead>
<tr>
<th>Topic</th>
<th>Description</th>
<th>Full-or-part-time:</th>
<th>Theory classes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bifurcations</td>
<td>Local bifurcations for planar vector fields and real maps. Saddle node and Hopf bifurcations.</td>
<td>10h</td>
<td>10h</td>
</tr>
<tr>
<td>Homoclinic points and chaotic Dynamics</td>
<td>Smale horseshoe. Homoclinic points and bifurcations. Hyperbolic sets and transversal homoclinic points. Dynamical systems with chaotic dynamics. Newhouse phenomenon.</td>
<td>10h</td>
<td>10h</td>
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<tr>
<td>Non-smooth systems</td>
<td>Introduction to non-smooth differential equations. Definition and motivating examples. Filippov's convention.</td>
<td>5h</td>
<td>5h</td>
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**GRADING SYSTEM**

The students have to do some problems (60%) and a research work (25%). There will be also a final exam covering on the theoretical part of the subject (15%). On the other hand they will attend the winter courses "Recent trends in non-linear science" and produce a document about them.

**EXAMINATION RULES.**

There will be a final exam covering the theoretical part of the course.

**BIBLIOGRAPHY**

**Basic:**