200213 - SD - Dynamical Systems

**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:** JOAQUIM PUIG SADURNI

**Others:**

- Primer quadrimestre:
  - AMADEU DELSHAMS I VALDES - M-A
  - GEMMA HUGUET CASADES - M-A
  - JOAQUIM PUIG SADURNI - M-A

### Prior skills

Basic knowledge about the theory of ordinary differential equations (developed in the course of Differential Equations).

Basic knowledge about the numerical resolution of ordinary differential equations (developed in the course of Numerical Calculus).

### Degree competences to which the subject contributes

**Specific:**

3. CE-2. Solve problems in Mathematics, through basic calculation skills, taking in account tools availability and the constraints of time and resources.

4. CE-4. Have the ability to use computational tools as an aid to mathematical processes.

5. Ability to solve problems from academic, technical, financial and social fields through mathematical methods.

13. CE-1. Propose, analyze, validate and interpret simple models of real situations, using the mathematical tools most appropriate to the goals to be achieved.

14. CE-3. Have the knowledge of specific programming languages and software.

**Generical:**

1. 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.

2. 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.

6. CG-1. Show knowledge and proficiency in the use of mathematical language.

7. CG-2. Construct rigorous proofs of some classical theorems in a variety of fields of Mathematics.

8. 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.

9. CG-4. Translate into mathematical terms problems stated in non-mathematical language, and take advantage of this translation to solve them.

10. CG-6 Detect deficiencies in their own knowledge and pass them through critical reflection and choice of the best
200213 - SD - Dynamical Systems

One aims that at the end of the course the student has a set of techniques and results that allow him/her to address the basic aspects of the description and analysis of dynamical systems, whether they are discrete or modeled through differential equations. Additionally, one aims at providing a broad vision of the different lines of applications and research that dynamical systems have (such as celestial mechanics, invariant objects, or mathematical biology) and the basic skills for their simulation and quantitative study through computational tools.

Transversal:
11. 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.
12. 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.

Teaching methodology

The course consists of four weekly hours that will be distributed in two hours per week focusing on theoretical aspects, explained in the contents section, and two hours devoted to applications, problem sessions and practical sessions.

In the practical classes there will be problems that, because of their relevance, will be solved by the professor on the blackboard, practical sessions with specific software for dynamical systems, which will be explained in a self-contained way, and sessions of previously selected problems that the students will solve on the blackboard and then deliver them in written form.

In order to favor the autonomous learning of students, they will be assigned, based on their preferences, an extension project that can be theoretical, numerical or mixed. The project will have to be presented, in front of the rest of students, in extraordinary sessions at the end of the course.

There will be an examination of review of contents at the end of the course where there will be both short theoretical questions and problems similar to those in class.

Learning objectives of the subject

One aims that at the end of the course the student has a set of techniques and results that allow him/her to address the basic aspects of the description and analysis of dynamical systems, whether they are discrete or modeled through differential equations. Additionally, one aims at providing a broad vision of the different lines of applications and research that dynamical systems have (such as celestial mechanics, invariant objects, or mathematical biology) and the basic skills for their simulation and quantitative study through computational tools.

Study load

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

<table>
<thead>
<tr>
<th>Module</th>
<th>Learning time: 17h</th>
</tr>
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<tbody>
<tr>
<td>One-dimensional Chaotic Dynamics</td>
<td>Theory classes: 4h</td>
</tr>
<tr>
<td></td>
<td>Laboratory classes: 4h</td>
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<tr>
<td></td>
<td>Self study: 9h</td>
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</tbody>
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**Description:**

<table>
<thead>
<tr>
<th>Module</th>
<th>Learning time: 17h</th>
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<tbody>
<tr>
<td>Lineal Systems</td>
<td>Theory classes: 4h</td>
</tr>
<tr>
<td></td>
<td>Laboratory classes: 4h</td>
</tr>
<tr>
<td></td>
<td>Self study: 9h</td>
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**Description:**

<table>
<thead>
<tr>
<th>Module</th>
<th>Learning time: 59h</th>
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<tbody>
<tr>
<td>Invariant objects of Flows and Diffeomorphisms</td>
<td>Theory classes: 10h</td>
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<tr>
<td></td>
<td>Laboratory classes: 10h</td>
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<tr>
<td></td>
<td>Self study: 39h</td>
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**Description:**

<table>
<thead>
<tr>
<th>Module</th>
<th>Learning time: 17h</th>
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<tbody>
<tr>
<td>Planar Flows</td>
<td>Theory classes: 4h</td>
</tr>
<tr>
<td></td>
<td>Laboratory classes: 4h</td>
</tr>
<tr>
<td></td>
<td>Self study: 9h</td>
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**Description:**
Global Dynamics

Learning time: 40h
- Theory classes: 8h
- Laboratory classes: 8h
- Self study: 24h

Description:
- Global invariant manifolds.
- Homoclinic and heteroclinic points.
- Smale's Horseshoe.
- Smale homoclinic theorem.
- Splitting of separatrices.
- Method of Poincaré-Melnikov-Arnol’d.
- Applications

Qualification system

There will be an exam at the end of the course where there will be both short theoretical questions and similar problems to the ones solved in class. The qualification of the exam will correspond to 35% of the final mark. The oral presentation and the written resolution of the assigned problems will be evaluated, as well as the participation in the practical sessions with computers. This mark will correspond to 25% of the final mark.

The project execution, written memory and oral presentation will be evaluated. The participation in the presentation of projects from the rest of students will also be evaluated. This part will contribute 40% to the final mark.

Regulations for carrying out activities

The assigned problems will be done individually. The project can be done in groups of up to two people.
Bibliography

Basic:


