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.
34961 - QQMDS - Quantitative and Qualitative Methods in Dynamical Systems

**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 perturvatives techniques to study a dynamical system globally.

**Learning objectives of the subject**

**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>Self study:</td>
<td>127h 30m</td>
<td>68.00%</td>
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### Content

| **Invariant objects in Dynamical Systems** | **Learning time:** 10h  
Theory classes: 10h |
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
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<tr>
<td>Continuous and discrete Dynamical Systems.</td>
<td></td>
</tr>
<tr>
<td>Poincaré map.</td>
<td></td>
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<tr>
<td>Local behaviour of hyperbolic invariant objects. Conjugation.</td>
<td></td>
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<tr>
<td>Invariant manifolds.</td>
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</tbody>
</table>

| **Normal forms**                          | **Learning time:** 10h  
Theory classes: 10h |
<table>
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</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
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<tr>
<td>Poincaré-Dulac normal forms. Convergence: Poincaré and Siegel domains.</td>
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</tbody>
</table>

| **Perturbation theory in Dynamical Systems** | **Learning time:** 15h  
Theory classes: 15h |
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<tbody>
<tr>
<td><strong>Description:</strong></td>
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</table>

| **Bifurcations**                           | **Learning time:** 10h  
Theory classes: 10h |
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<tbody>
<tr>
<td><strong>Description:</strong></td>
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<tr>
<td>Local bifurcations for planar vector fields and real maps. Saddle node and Hopf bifurcations.</td>
<td></td>
</tr>
</tbody>
</table>

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

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

**Description:**

**Description:**
- Local bifurcations for planar vector fields and real maps. Saddle node and Hopf bifurcations.
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 nonlinear science" and produce a document about them.

**Qualification system**

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

**Bibliography**

**Basic:**