Course guides  
200153 - CN - Numerical Calculus

Unit in charge: School of Mathematics and Statistics
Teaching unit: 749 - MAT - Department of Mathematics.  
748 - FIS - Department of Physics.

Degree: BACHELOR’S DEGREE IN MATHEMATICS (Syllabus 2009). (Compulsory subject).

Academic year: 2020  ECTS Credits: 7.5  Languages: Catalan

LECTURER

Coordinating lecturer: JUAN RAMON PACHA ANDUJAR

Others:  
Primer quadrimestre:  
MARIA MERCEDES OLLE TORNER - M-A, M-B  
JUAN RAMON PACHA ANDUJAR - M-A  
JUAN J. SANCHEZ UMBRIA - M-B

PRIOR SKILLS

Numerical linear algebra  
Programming  
Differential and integral calculus

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. CE-2. Solve problems in Mathematics, through basic calculation skills, taking in account tools availability and the constraints of time and resources.
2. CE-3. Have the knowledge of specific programming languages and software.
3. CE-4. Have the ability to use computational tools as an aid to mathematical processes.

General:
5. CB-1. Demonstrate knowledge and understanding in Mathematics that is founded upon and extends that typically associated with Bachelor’s level, and that provides a basis for originality in developing and applying ideas, often within a research context.
6. CB-2. Know how to apply their mathematical knowledge and understanding, and problem solving abilities in new or unfamiliar environments within broader or multidisciplinary contexts related to Mathematics.
7. CB-3. Have the ability to integrate knowledge and handle complexity, and formulate judgements with incomplete or limited information, but that include reflecting on social and ethical responsibilities linked to the application of their knowledge and judgements.
8. CG-1. Show knowledge and proficiency in the use of mathematical language.
10. 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.
11. CG-4. Translate into mathematical terms problems stated in non-mathematical language, and take advantage of this translation to solve them.
12. CG-6 Detect deficiencies in their own knowledge and pass them through critical reflection and choice of the best action to extend this knowledge.

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.
TEACHING METHODOLOGY

The module consists of 3h per week of theoretical sessions, where its different contents are exposed and discussed. These are supplemented, at the rate of 2 hours per week, with sessions of problems and practices, where the students will be able to develop the works that they will have to present throughout the course.

LEARNING OBJECTIVES OF THE SUBJECT

The course aims, first, to give the student an overview of the "classical" numerical methods on approximation, numerical integration, calculation of zeros of functions and nonlinear systems, as well as introducing numerical methods for solving differential equations; emphasizing the possibilities they offer us for solving problems that are difficult to deal with only with Algebra and Differential Calculus. However, one must be well aware that these methods provide approximations, not exact results. Therefore, a second goal is to give the student techniques that allow him to analyze the results obtained and to limit the errors that inevitably occur when using these tools.

From a practical point of view, through the problem sessions and the works, it is pursued, on the one hand, that the students assimilate the results exposed to the theory classes and, on the other hand, that they reach a certain degree of efficiency in the approach and in the resolution of problems, as well as initiative and sufficient technical competence at the time of implementing the methods studied in the form of programs (in C / C++ or Matlab, for example).

STUDY LOAD

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours large group</td>
<td>45,0</td>
<td>24.00</td>
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<tr>
<td>Hours small group</td>
<td>30,0</td>
<td>16.00</td>
</tr>
<tr>
<td>Self study</td>
<td>112,5</td>
<td>60.00</td>
</tr>
</tbody>
</table>

Total learning time: 187.5 h

CONTENTS

Approximation

Description:

Full-or-part-time: 43h
Theory classes: 12h
Laboratory classes: 8h
Self study : 23h
**Numerical integration**

**Description:**

**Full-or-part-time:** 39h
Theory classes: 10h
Laboratory classes: 7h
Self study: 22h

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**Solving nonlinear equations**

**Description:**

**Full-or-part-time:** 38h
Theory classes: 10h
Laboratory classes: 6h
Self study: 22h

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**Solving nonlinear systems**

**Description:**

**Full-or-part-time:** 29h
Theory classes: 4h
Laboratory classes: 3h
Self study: 22h

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**Introduction to numerical solution of ordinary differential equations**

**Description:**
§ Introduction. § Euler’s method. § Taylor's methods. § Runge-Kutta's methods. § Step control. § Applications. Basic integration of solutions, determination of periodic orbits and phase portraits of some classical models within dynamic systems (Van der Pol's oscillator, simple pendulum, Lotka-Volterra’s type equations, predator-prey systems, etc.)

**Full-or-part-time:** 38h
Theory classes: 9h
Laboratory classes: 6h
Self study: 23h
**GRADING SYSTEM**

Throughout the course, a set of practical works will be proposed. Submitting the practices, within the indicated period, will be compulsory in order to attend the module's assessment tests.

Thus, the grade of the module, \( N \), will be calculated from the marks obtained in the following three tests:

- A continuous assessment test, \( AC \), consisting of a practical exam.
- A partial exam, \( P \), which will be convened in the middle of the term.
- A final exam, \( F \).

according to the formula,

\[
N = 0.2 \ AC + 0.8 \ \max(F, 0.2P + 0.8F).
\]

**EXAMINATION RULES.**

**BIBLIOGRAPHY**

**Basic:**

**Complementary:**