200153 - CN - Numerical Calculus

Coordinating unit: 200 - FME - School of Mathematics and Statistics
Teaching unit: 749 - MAT - Department of Mathematics
751 - DECA - Department of Civil and Environmental Engineering

Academic year: 2018
Degree: BACHELOR’S DEGREE IN MATHEMATICS (Syllabus 2009). (Teaching unit Compulsory)
ECTS credits: 7,5  
Teaching languages: Catalan

Teaching staff

Coordinator: SONIA FERNANDEZ MENDEZ
Others: Primer quadrimestre:
SONIA FERNANDEZ MENDEZ - A, B
ABEL GARGALLO PEIRO - A, B
ESTHER SALA LARDIES - A, B

Opening hours

Timetable: To be announced at the beginning of the term.

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.

Generical:
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.
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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

Teaching activity consists of five hours per week, of which three in a standard classroom and two in a computer room. Classes in standard classrooms focus on derivations and more theoretical presentation, but always motivated by applications. The solutions of assigned problems and exercises are also carried out in these classes. Classes in the computer room are focused on coding and using numerical methods, and in illustrating the application of numerical techniques in computational engineering. The progress of practical assignments is also checked. All information relative to organisation and evolution of the module, and all teaching material is uploaded in the teaching intranet.

### Learning objectives of the subject

This module has two main goals: (1) to offer a global overview of the role of numerical methods in the solution of usual problems in mathematics, physics and engineering, and (2) to provide a solid background in the numerical solution of problems in scientific computing, complementing the contents of the module Numerical Linear Algebra.

Students should gain capacity to:
- Know and understand the possibilities, and the limitations, of numerical methods for the solution of problems in mathematics, physics and engineering.
- Understand the need to assure the quality of the output of interest, and be able to control the error in the numerical solution.
- Know and understand the basic numerical techniques for root finding and nonlinear systems of equations, as well as functional approximation and numerical integration.
- Know the fundamentals and understand the basic concepts of the numerical solution of differential equations.
- Choose and use an appropriate numerical method for the solution of a specific problem, identifying its advantages and drawbacks.
- Code numerical methods efficiently in a programming language (Matlab / Octave).
- Analyse in a critical manner the results obtained (accuracy in the output of interest, adequacy of the numerical method and the mathematical model, interpretation of results).
- Present results in a clear and concise way.
# Study load

<table>
<thead>
<tr>
<th>Total learning time: 187h 30m</th>
<th>Hours large group: 45h 24.00%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hours medium group: 0h 0.00%</td>
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<tr>
<td></td>
<td>Hours small group: 30h 16.00%</td>
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<tr>
<td></td>
<td>Guided activities: 0h 0.00%</td>
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<tr>
<td></td>
<td>Self study: 112h 30m 60.00%</td>
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</tbody>
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Last update: 19-09-2018
## 1. Root finding

**Learning time:** 23h 30m  
Theory classes: 6h  
Laboratory classes: 4h  
Self study: 13h 30m

**Description:**  

## 2. Nonlinear systems of equations

**Learning time:** 23h 30m  
Theory classes: 6h  
Laboratory classes: 4h  
Self study: 13h 30m

**Description:**  

## 3. Functional approximation

**Learning time:** 47h  
Theory classes: 12h  
Laboratory classes: 8h  
Self study: 27h

**Description:**  
General overview: motivation, approximant types, approximation criteria.  
Polynomial interpolation: fundamental theorem of algebra, existence and uniqueness of solution.  
Lagrange interpolation. Runge phenomenon.  
Piecewise interpolation (splines): characterization as a vectorial space, C0 linear, C1 cubic, C2 cubic and natural splines. Convergence and adaptivity properties.  
4. Numerical integration

**Learning time:** 36h
- Theory classes: 9h
- Laboratory classes: 6h
- Self study: 21h

**Description:**
General expression and order of a quadrature. Newton-Cotes quadratures; derivation of the trapezoidal rule and Simpson rule, error formula for equispaced points.

5. Introduction to numerical methods for differential equations

**Learning time:** 47h
- Theory classes: 12h
- Laboratory classes: 8h
- Self study: 27h

**Description:**
Boundary value problems. Introduction and applications. The shooting method.
Introduction to numerical methods for partial differential equations: finite differences, basic concepts on the finite element method.

**Qualification system**

The module is graded based on exams (E) and assignments proposed in the classroom (A), with a weighted average
\[ NF = 0.9E + 0.1A \]
were the grade for exams is
\[ E = \max(0.3\ EP + 0.7\ EF ,\ EF) \]
with a mid-term exam (EP) and a final exam (EF).
In the extraordinary call, E is the mark of the extraordinary exam.
Handing-in the assignments is not mandatory. Only assignments delivered in the fixed dates will be considered.
Bibliography

Basic:


Complementary: