Course guide
230454 - MNC1 - Numerical and Computational Methods 1

Unit in charge: Barcelona School of Telecommunications Engineering
Teaching unit: 748 - FIS - Department of Physics.
Degree: BACHELOR'S DEGREE IN ENGINEERING PHYSICS (Syllabus 2011). (Compulsory subject).
Academic year: 2022  ECTS Credits: 6.0  Languages: Catalan, Spanish

LECTURER

Coordinating lecturer: Consultar aquí / See here: https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/responsables-assignatura

Others: Consultar aquí / See here: https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/professorat-assignat-idioma

PRIOR SKILLS

Fundamental background in mathematics (polynomials, functions and differentiation)

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. Understanding and mastery of computer programming, use of operative systems and computational tools (scientific software). Skills to implement numerical algorithms in languages of low (C, F90) and high (Matlab) level.
2. Ability to solve problems in physics and engineering using fundamental numerical methods: experimental data processing, interpolation, roots of nonlinear equations, numerical linear algebra and optimization, quadrature and integration of differential equations, properly weighting their different aspects (accuracy, stability and efficiency or cost).
3. Ability to select numerical and optimization methods suitable for solving physical and engineering problems. Ability to apply the knowledge of numerical algorithms and optimization.

General:
4. ABILITY TO IDENTIFY, FORMULATE, AND SOLVE PHYSICAL ENGINEERING PROBLEMS. Planning and solving physical engineering problems with initiative, making decisions and with creativity. Developing methods of analysis and problem solving in a systematic and creative way.

Transversal:
1. TEAMWORK - Level 1. Working in a team and making positive contributions once the aims and group and individual responsibilities have been defined. Reaching joint decisions on the strategy to be followed.
2. EFFECTIVE USE OF INFORMATION RESOURCES - Level 1. Identifying information needs. Using collections, premises and services that are available for designing and executing simple searches that are suited to the topic.
3. SELF-DIRECTED LEARNING - Level 1. Completing set tasks within established deadlines. Working with recommended information sources according to the guidelines set by lecturers.

TEACHING METHODOLOGY

Lectures (2.6 ECTS): presentation of theoretical concepts and problem solving computer practicals with the individual/group participation of the students. Tutorials.
LEARNING OBJECTIVES OF THE SUBJECT

Numerical formulation of problems appearing in engineering physics, implementation of robust algorithms for their accurate resolution.

STUDY LOAD

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
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</thead>
<tbody>
<tr>
<td>Hours small group</td>
<td>26,0</td>
<td>17.33</td>
</tr>
<tr>
<td>Self study</td>
<td>85,0</td>
<td>56.67</td>
</tr>
<tr>
<td>Hours large group</td>
<td>39,0</td>
<td>26.00</td>
</tr>
</tbody>
</table>

Total learning time: 150 h

CONTENTS

1. Root searching of nonlinear equations

Description:
1.1 Local/global convergence and order of an iterative solver.
1.2 Derivative-free methods: bisection and secant.
1.3 Newton-Raphson method: domain of convergence.
1.4 Conditioning of nonlinear equations and convergence effects.

Full-or-part-time: 39h
Theory classes: 12h
Practical classes: 6h
Self study: 21h

2. Polynomial interpolation

Description:
2.1 Nodes and characteristic polynomial. Lagrange form.
2.2 Interpolation error. Runge instability (equiespaced nodes).
2.3 Barycentric interpolation. Barycentric weights. Theorem of Weiertrass.
2.4 Non-equispaced interpolation: Chebyshev.
2.5 Least Squares Adjustment: Linear Regression.

Full-or-part-time: 36h
Theory classes: 9h
Practical classes: 6h
Self study: 21h
### 3. Numerical differentiation

**Description:**
- 3.1 Equispaced Finite Difference: centered, forward and backwards.
- 3.2 Global and local interpolatory derivatives. Matrix differentiation.
- 3.3 Non-equispaced differentiation: Chebyshev.
- 3.4 Special applications: higher-order numerical derivatives.

**Full-or-part-time:** 36h  
Theory classes: 9h  
Practical classes: 6h  
Self study: 21h

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### 4. Numerical integration

**Description:**
- 4.1 Low order (local) equispaced quadratures: Newton-Cotes.
- 4.2 High-order (global) clustered quadratures: Clenshaw-Curtis.
- 4.3 Quadratures for improper integrals: Fejér, cotangent and tanH rules.
- 4.4 Applications to mechanics: one-dimensional dynamics, gravitational field, centers of mass and moments of inertia.

**Full-or-part-time:** 39h  
Theory classes: 9h  
Practical classes: 6h  
Guided activities: 3h  
Self study: 21h

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### GRADING SYSTEM

1. Mid term exam (EP): 30% relative weight on total grade.
2. Final exam (EF, covering all course contents): between 50% and 80% relative weight on total grade (see formula below).

**FINAL GRADE** = \( \max \{ 0.8 \times EF , 0.5 \times EF + 0.30 \times EP \} + 0.2 \times P \)

### BIBLIOGRAPHY

**Basic:**