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230454 - MNC1 - Numerical and Computational Methods 1

Coordinating unit: 230 - ETSETB - Barcelona School of Telecommunications Engineering
Teaching unit: 748 - FIS - Department of Physics
Academic year: 2019
Degree: BACHELOR'S DEGREE IN ENGINEERING PHYSICS (Syllabus 2011). (Teaching unit Compulsory)
ECTS credits: 6 Teaching languages: Catalan, Spanish

Teaching staff

Coordinator: Meseguer Serrano, Alvaro

Others: Batiste Boleda, Oriol
Alonso Maleta, Maria Aranzazu
Marques Truyol, Francisco

Prior skills

Fundamental background in mathematics (polynomials, functions and differentiation)

Degree competences to which the subject contributes

Specific:

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.
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).
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.

Generical:

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 INFORMATI0N 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

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Study load

Total learning time: 150h	Hours large group:	39h	26.00%
	Hours small group:	26h	17.33%
	Self study:	85h	56.67%

Content

1. Root searching of nonlinear equations	Learning time: 39h Theory classes: 12h Practical classes: 6h Self study : 21h

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.

2. Polynomial interpolation	Learning time: 36h Theory classes: 9h Practical classes: 6h Self study : 21h

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.

3. Numerical differentiation	Learning time: 36h Theory classes: 9h Practical classes: 6h Self study : 21h

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.

4. Numerical integration	Learning time: 39h Theory classes: 9h Practical classes: 6h Guided activities: 3h Self study : 21h
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.	

Qualification 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).

3. Computer problem solving (P) : 20% of relative weight.

FINAL GRADE = max{ 0.8 x EF , 0.5 x EF + 0.30 x EP } + 0.2 x P

Bibliography

Basic:

Quarteroni, A.; Saleri, F. Cálculo científico con Matlab y Octave [on line]. Milano: Springer, 2006 [Consultation: 16/06/2011]. Available on: <http://dx.doi.org/10.1007/978-88-470-0504-4>. ISBN 9788847005037.