250325 - METNUMER - Numerical Methods

<table>
<thead>
<tr>
<th>Coordinating unit:</th>
<th>250 - ETSECCPB - Barcelona School of Civil Engineering</th>
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</thead>
<tbody>
<tr>
<td>Teaching unit:</td>
<td>751 - DECA - Department of Civil and Environmental Engineering</td>
</tr>
<tr>
<td>Academic year:</td>
<td>2018</td>
</tr>
<tr>
<td>Degree:</td>
<td>BACHELOR'S DEGREE IN GEOLOGICAL ENGINEERING (Syllabus 2010). (Teaching unit Compulsory)</td>
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<tr>
<td>ECTS credits:</td>
<td>6</td>
</tr>
<tr>
<td>Teaching languages:</td>
<td>Catalan, Spanish</td>
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</tbody>
</table>

### Teaching staff

**Coordinator:** ALBERTO GARCIA GONZALEZ  
**Others:** ALBERTO GARCIA GONZALEZ

### Opening hours

**Timetable:** Office hours will be announced at the beginning of the course.

### Degree competences to which the subject contributes

**Specific:**

4050. Basic knowledge of computer use and programming, operating systems, databases and software as applied to engineering

**Transversal:**

- 592. EFFICIENT ORAL AND WRITTEN COMMUNICATION - Level 2. Using strategies for preparing and giving oral presentations. Writing texts and documents whose content is coherent, well structured and free of spelling and grammatical errors.
- 595. TEAMWORK - Level 2. Contributing to the consolidation of a team by planning targets and working efficiently to favor communication, task assignment and cohesion.
- 599. EFFECTIVE USE OF INFORMATION RESOURCES - Level 3. Planning and using the information necessary for an academic assignment (a final thesis, for example) based on a critical appraisal of the information resources used.
- 602. SELF-DIRECTED LEARNING - Level 3. Applying the knowledge gained in completing a task according to its relevance and importance. Deciding how to carry out a task, the amount of time to be devoted to it and the most suitable information sources.
- 584. 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.

### Teaching methodology

The course consists of 3.6 hours per week of classroom activity (large size group).

The 1.8 hours in the large size groups are devoted to theoretical lectures, in which the teacher presents the basic concepts and topics of the subject, shows examples and solves exercises.

The rest of weekly hours devoted to laboratory practice.

Support material in the form of a detailed teaching plan is provided using the virtual campus ATENEA: content, program of learning and assessment activities conducted and literature.

### Learning objectives of the subject
Students will acquire an understanding of the basic concepts of numerical methods, such as interpolation, integration and the solution of systems of equations. They will also learn how these concepts apply to basic and applied technological problems.

Upon completion of the course, students will be able to:
1. Use standard software to solve basic problems;
2. Use numerical analysis software to conduct sensitivity analyses of problems involving the solution of ordinary differential equations;
3. Use numerical techniques to solve engineering problems.

Numbers, algorithms and error analysis; Determination of zeros of functions; Solution of systems of equations using direct methods and basic iterative methods; Solution of nonlinear systems of equations; Eigenvalue problems: Approximation and interpolation; Numerical quadrature; Computers and programming, operating systems, databases and engineering software.

**Study load**

<table>
<thead>
<tr>
<th>Total learning time: 150h</th>
<th>Theory classes: 26h</th>
<th>17.33%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Practical classes: 8h</td>
<td>5.33%</td>
</tr>
<tr>
<td></td>
<td>Laboratory classes: 26h</td>
<td>17.33%</td>
</tr>
<tr>
<td></td>
<td>Guided activities: 6h</td>
<td>4.00%</td>
</tr>
<tr>
<td></td>
<td>Self study: 84h</td>
<td>56.00%</td>
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</tbody>
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## Content

<table>
<thead>
<tr>
<th>Introduction to Programming in Matlab</th>
<th>Learning time: 28h 47m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Laboratory classes: 12h</td>
</tr>
<tr>
<td></td>
<td>Self study : 16h 47m</td>
</tr>
</tbody>
</table>

### Description:
- Solving engineering problems with the computer

### Specific objectives:
- To know the Matlab environment.
- Being able to draw curves and surfaces using Matlab
- To know the basics of structured programming
- To know the flow control statements
- Being able to develop applications in Matlab

<table>
<thead>
<tr>
<th>Error propagation</th>
<th>Learning time: 9h 36m</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Theory classes: 2h</td>
</tr>
<tr>
<td></td>
<td>Laboratory classes: 2h</td>
</tr>
<tr>
<td></td>
<td>Self study : 5h 36m</td>
</tr>
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### Description:
- Number of significant digits. Error propagation.
- Case studies that show the problems generated by the propagation of rounding error.

### Specific objectives:
- To know the representation of integers and real numbers in the computer.
- Understand the concept and definitions of the error. To know that it can increase with the arithmetic operations
# Roots of nonlinear functions

**Description:**
Root finding techniques for solving problems in engineering
Solving root finding problems

**Specific objectives:**
Understand how iterative methods work and their requirements
To know the basic properties of Newton methods
Be able to choose the most appropriate method to solve an engineering problems. To analyze and interpret the numerical results.
Applying the knowledge acquired on iterative methods for zeros of functions to solve problems.

## Learning time:
19h 12m
- Theory classes: 4h
- Practical classes: 2h
- Laboratory classes: 2h
- Self study: 11h 12m

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# Solving systems of linear equations

**Description:**
Motivation. Classification of the methods. Solving trivial systems.
Applying linear system methods to solve engineering problems
Solving problems on methods for systems of linear equations.

**Specific objectives:**
Know the classification of methods for solving systems of linear equations.
To know the properties of the elimination methods.
To know the properties of the decomposition methods.
Be able to choose the most appropriate method to solve an engineering problems. To analyze and interpret the numerical results.
Understand how iterative methods can be used to solve a linear system and their requirements
To demonstrate knowledge and understanding of the conjugate gradient method and how to implement it.
Applying the knowledge about methods for systems of linear equations to solve problems.

## Learning time:
38h 24m
- Theory classes: 10h
- Practical classes: 2h
- Laboratory classes: 4h
- Self study: 22h 24m
## Approximation and interpolation

**Learning time:** 24h  
Theory classes: 6h  
Practical classes: 2h  
Laboratory classes: 2h  
Self study: 14h

### Description:

### Specific objectives:
Learn the criteria and the types of functional approximation and learn the properties and how to use the Lagrange interpolation. To know and use the polynomial sectional interpolation. Understand and know the basic properties of least squares problem. Be able to choose the most appropriate method to solve an engineering problems. To analyze and interpret the numerical results.

Applying the knowledge acquired on interpolation and approximation methods to solve problems.

## Numerical integration

**Learning time:** 24h  
Theory classes: 4h  
Practical classes: 2h  
Laboratory classes: 4h  
Self study: 14h

### Description:

### Specific objectives:
To know the classification of numerical integration methods. To understand the basics of Newton-Cotes quadratures. To know the advantages and disadvantages of composite quadratures. To understand the basics of Gauss quadratures. To know the convergence of studied quadratures. Be able to choose the most appropriate method to solve an engineering problems. To analyze and interpret the numerical results.

Applying the knowledge acquired on integration methods to solve problems.
Qualification system

The final grade of the course are obtained from the group assessment test (practical projects) and from the individual assessment tests (programming tees, exams,...).

During the course students will carry out several practical projects. At its completion the students will work in groups and will apply the acquired knowledge to solve engineering problems.

During the course there will be three individual assessment tests: a programming test and two exams. The programming test will consist on several exercises that students must solve using the computer. The exams will consist of a part with questions on concepts associated with learning objectives in terms of subject knowledge and understanding, and a set of application exercises.

The grade for the group assessment test or practical projects (GT) is the average grade for all practical projects.

The grade for individual assessment tests (IT) is the weighted average grade of the programming test and the exams, according to:

\[
IT = 0.16 \text{PT} + 0.28 \text{Ex1} + 0.28 \text{Ex2} + 0.28 \text{Ex3}
\]

where
- PT = Grade corresponding to the programming test
- EX1 = Grade corresponding to the first exam
- Ex2 = Grade corresponding to the second exam
- Ex3 = Grade corresponding to the third exam

The final grade for the course (FG) is calculated according to the expression:

\[
FG = GT^{(1/4)} \times IT^{(3/4)}
\]

Criteria for re-evaluation qualification and eligibility: Students that failed the ordinary evaluation and have regularly attended all evaluation tests will have the opportunity of carrying out a re-evaluation test during the period specified in the academic calendar. Students who have already passed the test or were qualified as non-attending will not be admitted to the re-evaluation test. The maximum mark for the re-evaluation exam will be five over ten (5.0). The non-attendance of a student to the re-evaluation test, in the date specified will not grant access to further re-evaluation tests. Students unable to attend any of the continuous assessment tests due to certifiable force majeure will be ensured extraordinary evaluation periods.

These tests must be authorized by the corresponding Head of Studies, at the request of the professor responsible for the course, and will be carried out within the corresponding academic period.

Regulations for carrying out activities

It is mandatory to pass this subject to submit all the reports corresponding to practical projects on due time.

Failure to perform an exam in the scheduled period will result in a mark of zero in that exam.
Bibliography

Basic:


Complementary:


