250325 - METNUMER - Numerical Methods

Coordinating unit: 250 - ETSECCPB - Barcelona School of Civil Engineering
Teaching unit: 751 - DECA - Department of Civil and Environmental Engineering
Academic year: 2015
Degree: BACHELOR'S DEGREE IN GEOLOGICAL ENGINEERING (Syllabus 2010). (Teaching unit Compulsory)
ECTS credits: 6
Teaching languages: Catalan, Spanish

Teaching staff
Coordinator: JOSE SARRATE RAMOS
Others: JESUS CORRAL LOPEZ, JOSE SARRATE RAMOS

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

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250325 - METNUMER - Numerical Methods

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>
</tr>
</tbody>
</table>
# 250325 - METNUMER - Numerical Methods

## Content

<table>
<thead>
<tr>
<th>Introduction to Programming in Matlab</th>
<th><strong>Learning time:</strong> 28h 47m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Laboratory classes: 12h</td>
</tr>
<tr>
<td></td>
<td>Self study : 16h 47m</td>
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</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><strong>Learning time:</strong> 9h 36m</th>
</tr>
</thead>
<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>
</tbody>
</table>

**Description:**
- 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

<table>
<thead>
<tr>
<th>Learning time:</th>
<th>19h 12m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes:</td>
<td>4h</td>
</tr>
<tr>
<td>Practical classes:</td>
<td>2h</td>
</tr>
<tr>
<td>Laboratory classes:</td>
<td>2h</td>
</tr>
<tr>
<td>Self study:</td>
<td>11h 12m</td>
</tr>
</tbody>
</table>

**Description:**

**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 engineering problems. To analyze and interpret the numerical results. Applying the knowledge acquired on iterative methods for zeros of functions to solve problems.

# Solving systems of linear equations

<table>
<thead>
<tr>
<th>Learning time:</th>
<th>38h 24m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes:</td>
<td>10h</td>
</tr>
<tr>
<td>Practical classes:</td>
<td>2h</td>
</tr>
<tr>
<td>Laboratory classes:</td>
<td>4h</td>
</tr>
<tr>
<td>Self study:</td>
<td>22h 24m</td>
</tr>
</tbody>
</table>

**Description:**

**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 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.
## Approximation and interpolation

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

**Description:**  
Introduction to sectional interpolation. General approach. Spline C0. Splines C1. Limitations of the interpolation with splines. 
Application of interpolation and approximation techniques to solve engineering problems. 
Solving problems on approximation and interpolation.

**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:**  
Applying numerical integration techniques to solve engineering problems. 
Solving problems on numerical integration.

**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.
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:

\[
FG = GT ^ (1 / 4) * IT ^ (3 / 4)
\]

Criteria for re-evaluation qualification and eligibility: Students that failed ordinary evaluation and have been regularly attending tests throughout the course will have the option to perform a re-evaluation test during the period specified in the academic calendar. The highest mark for the subject in the case of attending the evaluation exam will be five. In the case of justified absences to the regular evaluation tests that prevent the assessment of some parts of the contents of the subject, with prior approval of the Head of Studies, students may get evaluated by the re-evaluation test of the contents that have not been previously examined as well as the contents whose tests students have failed. The limitation on the maximum mark shall not apply to the parts assessed for the first time.

**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:


