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: 2019
Degree: BACHELOR'S DEGREE IN GEOLOGICAL ENGINEERING (Syllabus 2010). (Teaching unit Compulsory)
ECTS credits: 6
Teaching languages: Catalan, Spanish

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
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

| Total learning time: 150h | Theory classes: 26h 17.33% | Practical classes: 8h 5.33% | Laboratory classes: 26h 17.33% | Guided activities: 6h 4.00% | Self study: 84h 56.00% |
### Content

#### Introduction to Programming in Matlab

<table>
<thead>
<tr>
<th>Learning time: 28h 47m</th>
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<tr>
<td>Laboratory classes: 12h</td>
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<tr>
<td>Self study : 16h 47m</td>
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**Description:**
Arithmetic Operators and functions with arrays. Surface plotting.
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

#### Error propagation

<table>
<thead>
<tr>
<th>Learning time: 9h 36m</th>
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<tbody>
<tr>
<td>Theory classes: 2h</td>
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<tr>
<td>Laboratory classes: 2h</td>
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<tr>
<td>Self study : 5h 36m</td>
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</table>

**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...
<table>
<thead>
<tr>
<th>Roots of nonlinear functions</th>
<th>Learning time: 19h 12m</th>
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<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Theory classes: 4h</td>
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<tr>
<td>Theory classes: 4h</td>
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<tr>
<td>Practical classes: 2h</td>
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<tr>
<td>Laboratory classes: 2h</td>
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<td>Self study: 11h 12m</td>
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<tr>
<th>Solving systems of linear equations</th>
<th>Learning time: 38h 24m</th>
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<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Theory classes: 10h</td>
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<td>Practical classes: 2h</td>
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<tr>
<td>Laboratory classes: 4h</td>
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<tr>
<td>Self study: 22h 24m</td>
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<tr>
<th><strong>Specific objectives:</strong></th>
<th><strong>Specific objectives:</strong></th>
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<tr>
<td>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.</td>
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<tr>
<th><strong>Specific objectives:</strong></th>
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<tr>
<td>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.</td>
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## 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

**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.

**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 subject will be evaluated through two theoretical-practical exams (T1 and T2). All are strictly individual and not eliminatory. The exams will be held in computer rooms, consist of theory exercises, exercises to be solved and programming exercises, whose codes will have to be delivered through the Virtual Campus ATENEA at the end of the exam. - The T1 exam will be a partial exam and will take place approximately halfway through the second semester. The date and the exact contents that enter for the T1 exam will be published on the website of the Virtual Campus ATENEA at the beginning of the second semester. - The T2 exam will be a final exam, where it will enter the complete topics of the subject. The date of T2 exam will be published on the website of the Virtual Campus ATENEA at the beginning of the second semester. The final grade of the subject will be obtained following the following formula: Final Note = max (0.3 * T1 + 0.7 * T2, T2) if T1 greater than or equal to 2 over 10 Final Note = 0.3 * T1 + 0.7 * T2 if T1 < 2 out of 10 That is, it will be the maximum between the grade obtained by the calculation (0.3 * T1 + 0.7 * T2) or the grade of the final exam T2. To be eligible for this scoring criterion, the student must have obtained a minimum score of 2 out of 10 in T1, otherwise the final grade will necessarily be obtained by calculating NotaFinal = 0.3 * T1 + 0.7 * T2.

Good Practices and Behavior Academic dishonesty (including, among others, plagiarism and falsification of results) will be severely punished, in accordance with current academic regulations: any act of this nature implies a final grade of 0 in the subject. Criteria admission to reevaluation Students suspended in the regular evaluation will have the option to perform a re-evaluation test in the period set in the academic calendar. Students who have already passed it will not be able to take the re-evaluation test of the subject. In the same way, students who have not presented the exams of the ordinary evaluation will not be able to take the re-evaluation test of the subject. The maximum score in the case of taking the re-evaluation test will be five (5.0). The non-attendance of a student summoned to the re-evaluation test, held during the period established, may not lead to the performance of another test with a later date.

Bibliography

Basic:

Complementary: