820083 - SNAE - Numerical Simulation Applied to Engineering

**Coordinating unit:** 295 - EEBE - Barcelona East School of Engineering

**Teaching unit:** 748 - FIS - Department of Physics

**Academic year:** 2015

**Degree:**
- BACHELOR'S DEGREE IN ELECTRICAL ENGINEERING (Syllabus 2009). (Teaching unit Optional)
- BACHELOR'S DEGREE IN MECHANICAL ENGINEERING (Syllabus 2009). (Teaching unit Optional)
- BACHELOR'S DEGREE IN CHEMICAL ENGINEERING (Syllabus 2009). (Teaching unit Optional)
- BACHELOR'S DEGREE IN BIOMEDICAL ENGINEERING (Syllabus 2009). (Teaching unit Optional)
- BACHELOR'S DEGREE IN ENERGY ENGINEERING (Syllabus 2009). (Teaching unit Optional)
- BACHELOR'S DEGREE IN BIOMEDICAL ENGINEERING (Syllabus 2009). (Teaching unit Optional)
- BACHELOR'S DEGREE IN INDUSTRIAL ELECTRONICS AND AUTOMATIC CONTROL ENGINEERING (Syllabus 2009). (Teaching unit Optional)
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- BACHELOR'S DEGREE IN BIOMEDICAL ENGINEERING (Syllabus 2009). (Teaching unit Optional)
- BACHELOR'S DEGREE IN INDUSTRIAL ELECTRONICS AND AUTOMATIC CONTROL ENGINEERING (Syllabus 2009). (Teaching unit Optional)

**ECTS credits:** 3

**Teaching languages:** English

**Teaching staff**

**Coordinator:** Domingo García Senz

**Others:** Domingo García Senz

**Opening hours**

**Timetable:** consensuated with the professor.

**Prior skills**

Ability to work with the computer and a basic knowledge of a programming language.

**Requirements**

Basic knowledge of algebra, calculus and physics.

**Degree competences to which the subject contributes**

**Transversal:**

1. 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.

**Teaching methodology**

40 % Expositive methodology plus 35% individual work plus 25% working in group.

**Learning objectives of the subject**
820083 - SNAE - Numerical Simulation Applied to Engineering

To introduce the student into basic techniques of numerical simulation and their application to solve engineering problems.

**Study load**

<table>
<thead>
<tr>
<th>Total learning time: 75h</th>
<th>Hours large group: 30h</th>
<th>40.00%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Self study: 45h</td>
<td>60.00%</td>
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</table>
## Content

<table>
<thead>
<tr>
<th>Chapter: A primer on numerical calculus.</th>
<th>Learning time: 60h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 24h</td>
</tr>
<tr>
<td></td>
<td>Self study : 36h</td>
</tr>
</tbody>
</table>

**Description:**
- Interpolation, fitting.
- Applied matrix algebra (domain factorization, the homogeneous matrix of transformation, Markov chains).
- Numerical differentiation.
- Numerical resolution of differential equations.
- Stability (example: prey-predator dynamics).
- The fast Fourier transform FFT.

**Related activities:**
The last minutes of each session will be devoted to write easy programs of numerical calculus.

**Specific objectives:**
To introduce the student to the basic numerical techniques addressed to simulate physical and engineering systems.

<table>
<thead>
<tr>
<th>Chapter: Applications to several engineering disciplines.</th>
<th>Learning time: 60h</th>
</tr>
</thead>
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<td></td>
<td>Theory classes: 24h</td>
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<tr>
<td></td>
<td>Self study : 36h</td>
</tr>
</tbody>
</table>

**Description:**
- Description of articulate systems by means of the homogeneous matrix.
- Numerical solution of the Laplace equation and its application to electrostatic problems.
- Applications of the Laplace equation to the heat transfer problem.
- Simulation of a set of coupled chemical reactions network.
- Planets and satellites orbital elements.
- Signal analysis.
- Application of the Markov chains to the economy.

**Related activities:**
- A simulation program dealing to a physical system linked to engineering has to be written by the interested students as a part of the evaluation of the course. There will be a public exposition of the work done.

**Specific objectives:**
- Apply the main concepts already learnt in the previous chapter. Applications to interesting engineering problems will be carefully described.
### 3. Chapter: Simulation of discrete systems, bioengineering.

**Learning time:** 30h  
- Theory classes: 12h  
- Self study: 18h

**Description:**  
Discrete simulation. The game of life. Application to the study of virus replication. Fractal geometry and applications.

**Related activities:**  
The interested students have to write a simple program based on the discrete simulation methods as a main work of the course. There will be a specific session devoted to the exposition of the works done by the students at the end of the course.

**Specific objectives:**  
To introduce the student to this special class of simulation techniques where a set of empirical rules drive the evolution of a complex system settled in a 2D grid.

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### Qualification system

Two classroom exams P1 and P2 and a practical work, T, consisting in planify and devise a computer algorithm aimed at solving a particular engineering problem.

Final qualification: $0.25 \text{ P1} + 0.25 \text{ P2} + 0.5 \text{ T}$.

The generic competence will be evaluated taking into account: 1) The ability of the student to apply the concepts explained in the classroom to practical engineering problems, 2) the self-study abilities of the students, 3) abilities to make a public presentation and defend the work done. The weight of the generic competence within the evaluation of the course will be of 10%.

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### Bibliography

**Basic:**