200248 - MNED - Numerical Methods for Differential Equations

Coordinating unit: 200 - FME - School of Mathematics and Statistics
Teaching unit: 751 - DECA - Department of Civil and Environmental Engineering
Academic year: 2019
Degree: BACHELOR'S DEGREE IN MATHEMATICS (Syllabus 2009). (Teaching unit Optional)
ECTS credits: 6
Teaching languages: English

Teaching staff

Coordinator: JAUME SOLER VILLANUEVA

Others: Primer quadrimestre:
MATTEO GIACOMINI - M-A
JAUME SOLER VILLANUEVA - M-A

Degree competences to which the subject contributes

Specific:
3. CE-1. Propose, analyze, validate and interpret simple models of real situations, using the mathematical tools most appropriate to the goals to be achieved.
4. CE-2. Solve problems in Mathematics, through basic calculation skills, taking account tools availability and the constraints of time and resources.
5. CE-3. Have the knowledge of specific programming languages and software.

6. CE-4. Have the ability to use computational tools as an aid to mathematical processes.
7. Ability to solve problems from academic, technical, financial and social fields through mathematical methods.

General:
1. CB-4. Have the ability to communicate their conclusions, and the knowledge and rationale underpinning these to specialist and non-specialist audiences clearly and unambiguously.
2. To have developed those learning skills necessary to undertake further interdisciplinary studies with a high degree of autonomy in scientific disciplines in which Mathematics have a significant role.
8. CG-1. Show knowledge and proficiency in the use of mathematical language.


10. CG-3. Have the ability to define new mathematical objects in terms of others already know and ability to use these objects in different contexts.
11. CG-4. Translate into mathematical terms problems stated in non-mathematical language, and take advantage of this translation to solve them.
12. CG-6 Detect deficiencies in their own knowledge and pass them through critical reflection and choice of the best action to extend this knowledge.

Transversal:
13. ENTREPRENEURSHIP AND INNOVATION: Knowing about and understanding how businesses are run and the sciences that govern their activity. Having the ability to understand labor laws and how planning, industrial and marketing strategies, quality and profits relate to each other.
14. SUSTAINABILITY AND SOCIAL COMMITMENT. Being aware of and understanding the complexity of social and economic phenomena that characterize the welfare society. Having the ability to relate welfare to globalization and sustainability. Being able to make a balanced use of techniques, technology, the economy and sustainability.
15. EFFICIENT ORAL AND WRITTEN COMMUNICATION. Communicating verbally and in writing about learning outcomes, thought-building and decision-making. Taking part in debates about issues related to the own field of specialization.
16. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.
17. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.

### Teaching methodology

(Section not available)

### Learning objectives of the subject

(Section not available)

### Study load

<table>
<thead>
<tr>
<th>Total learning time: 150h</th>
<th>Hours large group: 30h</th>
<th>20.00%</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Hours medium group: 0h</td>
<td>0.00%</td>
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<tr>
<td></td>
<td>Hours small group: 30h</td>
<td>20.00%</td>
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<tr>
<td></td>
<td>Guided activities: 0h</td>
<td>0.00%</td>
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<tr>
<td></td>
<td>Self study: 90h</td>
<td>60.00%</td>
</tr>
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</table>
## Content

<table>
<thead>
<tr>
<th>1. Ordinary equations. Basic concepts. Truncation error and order of a method. Convergence</th>
<th><strong>Learning time:</strong> 15h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes: 3h</td>
<td>Laboratory classes: 3h</td>
</tr>
<tr>
<td>Guided activities: 2h</td>
<td>Self study: 7h</td>
</tr>
<tr>
<td><strong>Description:</strong></td>
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<table>
<thead>
<tr>
<th>2. Runge-Kutta and Linear Multistep methods. Implementation.</th>
<th><strong>Learning time:</strong> 24h</th>
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<tbody>
<tr>
<td>Theory classes: 6h</td>
<td>Laboratory classes: 6h</td>
</tr>
<tr>
<td>Guided activities: 3h</td>
<td>Self study: 9h</td>
</tr>
<tr>
<td><strong>Description:</strong></td>
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<tr>
<th>3. Stiff problems</th>
<th><strong>Learning time:</strong> 18h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes: 3h</td>
<td>Laboratory classes: 3h</td>
</tr>
<tr>
<td>Guided activities: 3h</td>
<td>Self study: 9h</td>
</tr>
<tr>
<td><strong>Description:</strong></td>
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<thead>
<tr>
<th>4. Partial Differential Equations (PDE). Generalities on their solution</th>
<th><strong>Learning time:</strong> 26h</th>
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<tbody>
<tr>
<td>Theory classes: 5h</td>
<td>Laboratory classes: 5h</td>
</tr>
<tr>
<td>Guided activities: 4h</td>
<td>Self study: 12h</td>
</tr>
<tr>
<td><strong>Description:</strong></td>
<td></td>
</tr>
<tr>
<td>Problems in engineering and the applied sciences requiring numerical solution of PDE. Linear 2nd order PDE: classification, physical interpretation. Fundamental aspects of their numerical solution. Boundary conditions.</td>
<td></td>
</tr>
</tbody>
</table>
5. Numerical solution of PDE with the Finite Difference Method (FDM)

**Learning time:** 26h
- Theory classes: 5h
- Laboratory classes: 5h
- Guided activities: 4h
- Self study: 12h

**Description:**


**Learning time:** 26h
- Theory classes: 5h
- Laboratory classes: 5h
- Guided activities: 4h
- Self study: 12h

**Description:**

7. Quality control of solutions

**Learning time:** 15h
- Theory classes: 3h
- Laboratory classes: 3h
- Guided activities: 2h
- Self study: 7h

**Description:**
Need for ensuring the quality of the solution. Concepts of verification and validation. Basic concepts for error estimates, estimate of quantities of interest. Remeshing and adaptivity.

**Qualification system**
The final mark is given as a number from 0 to 10 (less than 5: fail; 5 or higher: pass; 8 to 10: excellent) obtained as the sum of three marks:
1) Coursework and public presentation of part of it: up to 3 points.
2) Short presentations given in class during the course: up to 1 point.
3) Written exams: up to 6 points.
Regulations for carrying out activities

Attending a minimum of lessons is compulsory. Coursework and is compulsory as well as giving a short talk in class during the course.

Bibliography

Basic:

Complementary: