Course guide
2500221 - GEA0221 - Numerical Modeling

Unit in charge: Barcelona School of Civil Engineering
Teaching unit: 751 - DECA - Department of Civil and Environmental Engineering.
Degree: BACHELOR'S DEGREE IN ENVIRONMENTAL ENGINEERING (Syllabus 2020). (Compulsory subject).
Academic year: 2022
ECTS Credits: 6.0
Languages: Spanish

LECTURER
Coordinating lecturer: ESTHER SALA LARDIES
Others: IRENE ARIAS VICENTE, JUAN SALVADOR LATORRE SÁNCHEZ, SERGI PÉREZ ESCUDERO, ESTHER SALA LARDIES

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
14446. Solve mathematical problems that may arise in engineering by applying knowledge about: linear algebra, geometry, differential geometry, differential and integral calculus, optimization, ordinary differential equations.
14447. Obtain basic knowledge about the use and programming of computers, operating systems, databases and basic numerical calculation and applied to engineering.
14448. Manage the basic concepts about the general laws of mechanics and thermodynamics, concept of field and heat transfer, and apply them to solve engineering problems.
14450. Describe the global functioning of the planet: atmosphere, hydrosphere, lithosphere, biosphere, anthroposphere, biogeochemical cycles (C, N, P, S), soil morphology and apply it to problems related to geology, geotechnics, edaphology and climatology.
14453. Describe and apply the techniques of analysis of physical, chemical and biological parameters; Integrate the experimental evidence found in field and / or laboratory data with the theoretical knowledge and interpret its results.
14457. Identify the fundamentals of structure theory, sustainable procedures for construction and dismantling of buildings and civil works; and describe the technology bases of the materials used in construction.
14458. Apply the methodologies of studies and evaluations of environmental impact and, in general, of environmental technologies, sustainability and waste treatment and of the management of international standards of environmental quality. Life cycle analysis, carbon footprint and water footprint and assess natural hazards (river, coastal floods, droughts, fires, soil erosion and landslides).
14459. Describe the components and modes of transport and the impact of their externalities on the environment; identify the principles of environmental management of transport systems and sustainable planning of the territory; and introduce the tools for the management and operation of transport systems.
14461. Analyze, design, simulate and optimize processes and systems with environmental relevance, both natural and artificial, and their resolution techniques, as well as recognize techniques for analysis and evaluation of climate change.
14465. Identify renewable energy generation techniques and energy transition concept.

Generical:
14440. Identify, formulate and solve problems related to environmental engineering.
14441. Apply the functions of consulting, analysis, design, calculation, project, construction, maintenance, conservation and exploitation of any action in the territory in the field of environmental engineering.
14442. To use in any action in the territory proven methods and accredited technologies, in order to achieve the greatest efficiency respect for the environment and the protection of the safety and health of workers and users.
TEACHING METHODOLOGY

The course consists of 4 hours per week of classroom activity, including some theoretical lectures (in which the teacher presents the basic concepts and topics of the subject and shows examples) and some laboratory or exercises (devoted to solve practical exercises).

This is a face-to-face module and participation and classwork are taken into account on the evaluation.

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.

Although most of the sessions will be given in the language indicated, sessions supported by other occasional guest experts may be held in other languages.

LEARNING OBJECTIVES OF THE SUBJECT

An analysis of the main mathematical models, including partial differential equation for simulation in the area of inland, sewage and marine waters, terrain, biochemistry or the atmosphere, is carried out. The main solution techniques are described, emphasizing the existing computing tools and the validation and verification criteria of the solutions obtained.

1. Know the main mathematical models for simulation in the field of environmental engineering (hydraulics, terrain, bio-chemistry, atmosphere, etc), as well as having notions of the techniques for their resolution (finite differences, finite volumes, finite elements).
2. Use existing calculation tools, applied to real cases, and understand the validation and verification criteria of the solutions obtained.

Numerical Modeling. An analysis of the main mathematical models will be carried out for simulation in the areas of inland, sewage and marine waters, terrain, biochemistry or the atmosphere. The main resolution techniques will be described, emphasizing the use of existing calculation tools and the validation and verification criteria of the solutions obtained.

STUDY LOAD

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours large group</td>
<td>30,0</td>
<td>20.00</td>
</tr>
<tr>
<td>Self study</td>
<td>84,0</td>
<td>56.00</td>
</tr>
<tr>
<td>Hours small group</td>
<td>15,0</td>
<td>10.00</td>
</tr>
<tr>
<td>Hours medium group</td>
<td>15,0</td>
<td>10.00</td>
</tr>
<tr>
<td>Guided activities</td>
<td>6,0</td>
<td>4.00</td>
</tr>
</tbody>
</table>

**Total learning time:** 150 h
CONTENTS

**Numerical integration**

**Description:**
- Definition of numerical quadrature
- Order of a quadrature
- Newton-Cotes quadratures: trapezoidal and Simpson rules
- Gauss quadratures
- Composite quadratures
- Problem solving
- Calculation of quadratures in Matlab
- Numerical integration applications

**Full-or-part-time:** 31h 12m
- Theory classes: 6h
- Practical classes: 5h
- Laboratory classes: 2h
- Self study: 18h 12m

**Partial differential equations**

**Description:**
- Definition
- Classification
- Separation of variables
- Problem solving
- Practical exercises

**Full-or-part-time:** 31h 12m
- Theory classes: 8h
- Practical classes: 5h
- Self study: 18h 12m

**Finite differences**

**Description:**
- Introduction to the finite difference method
- Solution of diffusion problems
- Programming and simulation
- Solving convection-diffusion problems

**Full-or-part-time:** 31h 12m
- Theory classes: 6h
- Practical classes: 3h
- Laboratory classes: 4h
- Self study: 18h 12m
Finite element method

**Description:**
Weak form
Discretization: approximation of the solution and system of equations (Galerkin)
General formulation for the simulation
Problem solving
Simulation of environmental problems

**Full-or-part-time:** 38h 24m
Theory classes: 10h
Practical classes: 2h
Laboratory classes: 4h
Self study: 22h 24m

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**Evaluation**

**Full-or-part-time:** 12h
Laboratory classes: 5h
Self study: 7h

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**GRADING SYSTEM**

The final mark of the subject is computed as
Final mark = 0.25 * NA + 0.75 * NE
where NA corresponds to practical works and NE to exams.

The NA grade is obtained as the average of the marks of different activities proposed during the course (exercises, directed assessments.... ). These activities may be carried out individually or in groups, and this will be indicated when proposing each activity.

The exams mark NE is obtained from the qualification of two strictly individual tests:
- The NE1 exam is taken approximately halfway through the semester and it includes the topics covered so far
- The NE2 exam is a final exam, which includes all the topics covered in the course.

With these grades, the exams mark is obtained as
NE = max(0.3*NE1 + 0.7*NE2, NE2) if NE1 is greater than or equal to 2 out of 10
NE = NE2 if NE1 is smaller than 2 out of 10.

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**EXAMINATION RULES.**

They will be discussed in class

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**BIBLIOGRAPHY**

**Basic:**