Course guide
2500221 - GEA0221 - Numerical Modeling

Last modified: 01/10/2023

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: 2023 **ECTS Credits:** 6.0 **Languages:** Spanish

LECTURER

Coordinating lecturer: ESTHER SALA LARDIES

Others: ALBERTO GARCIA GONZALEZ, 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 ou.t 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

Type	Hours	Percentage
Hours small group	15,0	10.00
Hours medium group	15,0	10.00
Self study	90,0	60.00
Hours large group	30,0	20.00

Total learning time: 150 h

CONTENTS

Partial differential equations

Description:
Definition and classification. Boundary conditions
Separation of variables
Examples of PDEs modelling environmental problems
Practical exercises

Full-or-part-time: 24h
Theory classes: 8h
Laboratory classes: 2h
Self study : 14h

Finite differences

Description:
- Difference operators
- Heat equation. Discretization in space and time. Explicit/implicit methods. Stability
- Transport equation. Treatment of the convective term
Solution of diffusion problems
Simulation: finite differences solution of the heat equation
Solving transport problems
Simulation: convection-diffusion equations

Full-or-part-time: 57h 35m
Theory classes: 12h
Practical classes: 6h
Laboratory classes: 6h
Self study : 33h 35m

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: 52h 48m
Theory classes: 10h
Practical classes: 4h
Laboratory classes: 8h
Self study : 30h 48m

Evaluation

Full-or-part-time: 9h 36m
Laboratory classes: 4h
Self study : 5h 36m

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).

Students suspended to the ordinary assessment that have been submitted regularly to the evaluation tests of the subject suspended will have the option to carry out a reassessment test in the period set in the academic calendar. Students who have already passed the qualification as not yet submitted may not be submitted to the re-evaluation test of a subject. The maximum qualification in the case of re-evaluation will be five (5.0). The non-attendance of a student summoned to the test of re-evaluation, celebrated in the fixed period, will not be able to give rise to the accomplishment of another test with later date.

EXAMINATION RULES.

Extraordinary assessments will be made for students who have not been able to complete some of the continuous assessment tests because of their proven accreditation. These tests must be authorized by the corresponding head of studies, at the request of the professor responsible for the subject, and will be carried out within the corresponding teaching period.
Once each exam has been completed, there is the possibility that a student may be called to conduct an oral interview as validation of their written exam, this interview being on the subject of the exam. In case of not obtaining a satisfactory assessment in the interview, the exam will be given as suspended with a grade of zero.

BIBLIOGRAPHY

Basic:
- Hoffman, J.D.. Numerical methods for engineers and scientifists. 2nd ed. New York: Marcel Dekker, 2001. ISBN 0824704436.
- Farlow, S.J. Partial differential equations for scientists and engineers. New York: Dover, 1993. ISBN 048667620X.