Course guide
250672 - 250672 - Modelling of Environmental Systems

Last modified: 22/05/2025

Unit in charge: Barcelona School of Civil Engineering
Teaching unit: 758 - EPC - Department of Project and Construction Engineering.

Degree: MASTER'S DEGREE IN ENVIRONMENTAL ENGINEERING (Syllabus 2014). (Compulsory subject).

Academic year: 2025 **ECTS Credits:** 5.0 **Languages:** Spanish

LECTURER

Coordinating lecturer: JOSE M. BALDASANO RECIO

Others: JOSE M. BALDASANO RECIO

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
13340. Apply scientific concepts to environmental problems and their correlation with technological concepts.
13341. Analyze systems, environmental problems and their resolution using models and evaluate them.
13342. Acquire basic skills of laboratory work and identify the methods and instrumentation for the determination of parameters relevant to the analysis of environmental problems.

Transversal:
8562. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

8563. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

TEACHING METHODOLOGY

The course consists of 3 hours a week of classes in a classroom.
The 2 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 1 hour is devoted to solving practical problems with greater interaction with the students. The objective of these practical work and exercises is to consolidate the general and specific learning objectives.
Support material in the form of detailed teaching plan is used by: 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

CE01 - Apply scientific concepts to environmental problems and their correlation with technological concepts.
CE02 - Analyze systems, environmental problems and their resolution using models and evaluate them.
CE03 - Acquire basic skills of laboratory work and identify the methods and instrumentation for the determination of parameters relevant to the analysis of environmental problems.

Very aware of the structure of land, water and artificial ecosystems and their interactions.
Meet the ecology and the cycling of elements.

Meet the major environmental problems globally.
Analyzes energy bases, stoichiometric and kinetic of different processes.
Modeling process and quantifies the performance and efficiency of systems.
Determines the basis of environmental hazards to human health and ecosystems.
Apply material balances and energy to environmental problems.
Interprets water-rock and water - air interactions using thermodynamic and kinetic methods.
Meet the pollutants and identify their impact.
Learn the basics of how the atmosphere and applies them in maintaining air quality.
Learn the basics of climate and discusses the implications of current climate change.
Conceptualized an environmental problem described by equations and poses analytical or numerical solution.
Identifies the codes you need to solve a problem as conceptualized.
Recognizes the spatial and temporal scales required to resolve the problem.
Is familiar with solutions to problems relating to dynamical systems.
Learn about simple solutions to problems advection- dispersion - reaction.
Recognizes the existence of uncertainty in the parameters of the equations and is capable of performing an uncertainty analysis and sensitivity.
Learn methods for information and action on various parameters or variables.
Understand that any measure inherently carries an associated error and is able to work with them.
It is critical to the values reported by others when the measurement method is not specified.
He has worked in the laboratory measurement of some parameters of environmental interest.

Introduction to numerical modeling process:
Operation of natural processes.
Defining and understanding the problem.
The process of modeling.
Stages in the development of a numerical model.
The boundaries of a model.
The transport equation.
Spatial and temporal scales: Euler vs Lagrange.
Modelling of dynamic systems:
Modeling of dynamic systems.
Models of water quality in rivers and reservoirs.
Air Quality Models: emissions.
Models of dispersion of pollutants in air.
Photochemical models.
Evaluation Model:
Calibration / verification / validation model.
Evaluation of results.
Uncertainty analysis.

Introduction to numerical modelling process:
Operation of natural processes. Defining and understanding the problem.
The modelling process.
Stages in the development of a numerical model.
The limits of a model.
The transport equation.
Spatial and temporal scales: Euler vs. Lagrange.
Modeling dynamical systems:
Models of water quality in rivers and reservoirs.
Air quality models: emissions.
Models of dispersion of pollutants in air.
Photochemical models.
Evaluation models: calibration / verification / validation of the model.
Evaluation of the results.
Uncertainty analysis.

STUDY LOAD

Type	Hours	Percentage
Self study	80,0	63.95
Hours small group	9,8	7.83
Hours large group	25,5	20.38
Hours medium group	9,8	7.83

Total learning time: 125.1 h

CONTENTS

01 Introduction to numerical modeling process

Description:
Introduction to numerical modeling process:
* Operation of natural processes.
* Defining and understanding the problem.
* The modeling process.
Exercises and practical work

Full-or-part-time: 7h 11m
Theory classes: 2h
Practical classes: 1h
Self study : 4h 11m

02 Stages in the development of a numerical model

Description:
Stages in the development of a model
The limits of a model
Exercises and practical work

Full-or-part-time: 4h 48m
Theory classes: 1h
Practical classes: 1h
Self study : 2h 48m

03 The transport equation

Description:
Concept of balance
Continuity Equation
Quantity Equation Conservation Movement
Equation of Conservation of Energy
Continuity equation of matter
Exercises and practical work

Full-or-part-time: 7h 11m
Theory classes: 2h
Practical classes: 1h
Self study : 4h 11m

04 Spatial and temporal scales: Euler vs. Lagrange

Description:
The spatial scales
The time cycles
Eulerian vs Lagrangian Scheme
Exercises and practical work

Full-or-part-time: 4h 48m
Theory classes: 1h
Practical classes: 1h
Self study : 2h 48m

12 Evaluation

Full-or-part-time: 16h 48m
Laboratory classes: 7h
Self study : 9h 48m

05 Water Quality Models: rivers and reservoirs

Description:
Classification of water quality models (WQM)
Criteria for the classification of WQM
historical development
Dynamics and processes: cycles
Basic components of the MCA
Self-purification process
Simplified temperature model for rivers
Model QUAL2E
Reservoir temperature and hydrodynamics
Water quality model for a reservoir
Exercises and practical work

Full-or-part-time: 7h 11m
Theory classes: 2h
Practical classes: 1h
Self study : 4h 11m

06 Air quality models: emissions

Description:
Types and models of emission inventory
Activity factor, emission sources, typology
Emission Factors
Emission sources of air pollutants
Approach top-down vs bottom-up
SNAP nomenclature groups
Criteria breakdown
Criteria of quality analysis inventory
Speciation
Exercises and practical work

Full-or-part-time: 7h 11m
Theory classes: 2h
Practical classes: 1h
Self study : 4h 11m

07 Models of pollutant dispersion

Description:
Historical development
Gaussian model
Lagrangian model
Box Model
Eulerian model
Exercises and practical work

Full-or-part-time: 7h 11m
Theory classes: 2h
Practical classes: 1h
Self study : 4h 11m

08 Photochemical models

Description:
Ozone Formation
Formation of secundary aerosols
Chemical mechanisms
Exercises and practical work

Full-or-part-time: 7h 11m
Theory classes: 2h
Practical classes: 1h
Self study : 4h 11m

09 Evaluation of models: calibration, verification, validation

Description:
Evaluation Process
Calibration / Verification / Validation /
Hindcast
Exercises and practical work

Full-or-part-time: 4h 48m
Theory classes: 1h
Practical classes: 1h
Self study : 2h 48m

10 Performance: metrics

Description:
Variables to evaluate
Metrics
Thresholds / Data Quality
Categorical statistical
Statistical Discrete
Diagram Taylor
Graphics
Exercises and practical work

Full-or-part-time: 7h 11m
Theory classes: 2h
Practical classes: 1h
Self study : 4h 11m

11 Analysis of uncertainty

Description:
Evaluation criteria
Uncertainty Analysis
Acceptance Criteria
Sensitivity Analysis
Model intercomparison

Full-or-part-time: 2h 24m
Theory classes: 1h
Self study : 1h 24m

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GRADING SYSTEM

The course grade will be obtained from continuous assessment scores and corresponding practical work.
Continuous assessment consists in several activities, both individually and in group, of additive and formative characteristics, carried out during the course (in the classroom and beyond).
The evaluation tests consist of a part with basic issues and questions about concepts associated with the learning objectives of the course with in terms of knowledge or understanding concepts, and a set of exercises for understanding and application.
The teaching takes place according to the following criteria:
NF = r*NE +(1-r)*NAC r = 0,5
NAC = q*NAEP +(1-q)*NACET q = 0,5

NF: Final Note
NE: Exam Note
NAC: Note from continuous assessment
NAEP: Note teachings practical assessment (works, presentations, etc.)
NACET: Note continued evaluation of the theoretical teachings (test, etc.)

EXAMINATION RULES.

Failure to perform practical work, laboratory or continuous assessment activity in the scheduled period will result in a mark of zero in that activity.

BIBLIOGRAPHY

Basic:
- Chapra, S.C. Surface water-quality modeling. New York: McGraw-Hill Companies, 1997. ISBN 0070113645.
- Zannetti, P. Air pollution modeling : theories, computational methods and available software. Southampton: Computational Mechanics Publications, 1990. ISBN 1853121002.
- Pielke, R.A. Mesoscale meteorological modeling. 3rd ed. San Diego, CA: Academic Press, 2013. ISBN 9780123852373.
- De Visscher, Alex. Air Dispersion Modeling Foundations and Applications [on line]. Hoboken, New Jersey: John Wiley, 2014 [Consultation: 21/02/2023]. Available on: https://onlinelibrary-wiley-com.recursos.biblioteca.upc.edu/doi/book/10.1002/9781118723098. ISBN 9781118723098.