Course guide
250801 - 250801 - Modelling in Geoengineering

Last modified: 22/05/2024

Unit in charge: Barcelona School of Civil Engineering
Teaching unit: 751 - DECA - Department of Civil and Environmental Engineering.

Degree: MASTER'S DEGREE IN GEOTECHNICAL ENGINEERING (Syllabus 2015). (Compulsory subject).

Academic year: 2024 **ECTS Credits:** 5.0 **Languages:** Spanish

LECTURER

Coordinating lecturer: JEAN VAUNAT

Others: JEAN VAUNAT

TEACHING METHODOLOGY

The course consists of 3 hours per week of classroom activity (large size group).

The 1 hour 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 2 hours in the medium size groups is devoted to solving practical problems with greater interaction with the students. The objective of these practical exercises is to consolidate the general and specific learning objectives.

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

To conceive soils and rocks as porous media governed by Solid and Fluid Mechanics.
To characterize the geological environment and its interaction with civil works.
To interpret laboratory tests and field observations so as to identify the mechanisms responsible for soil response. To propose laboratory testing programmes.
To formulate and implement Finite Element and Finite Differences numerical models with the objective to analyze the processes that govern ground response, to interpret field information and to predict soil response.

* To recognize the problems in Civil Engineering.
* To relate the problems in Civil Engineering to the characteristics of the geological environment.
* To conceptualize the problem in Civil Engineering in order to analyze, model and solve them.
* To apply continuum media concepts to analyze and model problems in Civil Engineering.
* To apply numerical techniques to solve Civil Engineering problems.

- Definition of a model. Modelling frameworks.
- Methods to approximate derivatives. Application to Geo-Engineering problems governed by ordinary differential equations.
- Finite differences method. Application to flow problems in soils.
- Methods to approximate integrals. Application to semi-analytical solutions in Geo-engineering.
- Finite elements method. Application to mechanical problems in Geo-Engineering.
- Methods to solve non-linear systems. Application to coupled problems in Geo-Engineering by means of the Finite Element Method.

STUDY LOAD

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

Total learning time: 125.1 h

CONTENTS

Introduction

Description:
I
Choosing a physical problem
Formulation of the equations
Obtaining the analytical solution

Specific objectives:
To formulate problems in the field of Geotechnical engineering in view of its numerical resolution
To formulate Geotechnical Engineering problems in the form of equations

Full-or-part-time: 9h 36m
Theory classes: 1h
Practical classes: 3h
Self study : 5h 36m

Solving flow problems using the Finite Difference method

Description:
Classification of differential equations
Approximation of derivatives
Discretization of the derivative of the ODE
Numerical solution
Comparison with the analytical solution
Description of the Finite Difference method
Discretization schemes
Numerical solution of the mass balance equation
Selection of a flow problem
Formulation of the equations
Obtaining an analytical, semi-analytical or empirical solution

Specific objectives:
To workout discretization methods for derivatives and their characteristics
To solve numerically an ODE
To solve mass balance equation using the Finite Difference method
To formulate an EDP in Geotechnical Engineering

Full-or-part-time: 31h 12m
Theory classes: 4h
Practical classes: 7h
Laboratory classes: 2h
Self study : 18h 12m

Solving mechanical problems using the Finite Element method

Description:
Methods for integral approximation
Bibliographic search of a semi-analytical solution for problem 3
Numerical computation of the integral
Calculation of the semi-analytical solution
Introduction to the Finite Element method
Theoretical considerations
The theorem of virtual work
Spatial discretization
Application of the boundary conditions
Basic programming in Matlab
Numeric tools available in Matlab
Data reading tools and print / display results
Structure of an EF program
Formulation of two uni-dimensional mechanical problems (settlements for a multi-layer elastic ground, deformation of a diaphragm wall under earth-pressure).
Programming in Matlab of a program to solve the two problems in a unified way.

Specific objectives:
To compute numerically integrals
To compute numerically integrals
To solve mechanical problems using the Finite Element method
To code in Matlab a Finite Element program solving a mechanical problem
Program a Finite Elements code to solve mechanical problems in Geotechnical Engineering

Full-or-part-time: 52h 48m
Theory classes: 18h
Practical classes: 2h
Laboratory classes: 2h
Self study : 30h 48m

Solving coupled problems in Geotechnical Engineering

Description:
Formulation of the consolidation equation
Analytical solution
Resolution through Finite Difference and Finite Element methods
More general coupled problems (2D, 3D, multiphysics)

Specific objectives:
To solve coupled problems in Geotechnical Engineering

Full-or-part-time: 14h 23m
Theory classes: 6h
Self study : 8h 23m

GRADING SYSTEM

The mark of the course is obtained from the ratings of continuous assessment and their corresponding laboratories and/or classroom computers.

Continuous assessment consist in several activities, both individually and in group, of additive and training characteristics, carried out during the year (both in and out of the classroom).

The teachings of the laboratory grade is the average in such activities.

The evaluation tests consist of a part with questions about concepts associated with the learning objectives of the course with regard to knowledge or understanding, and a part with a set of application exercises.

EXAMINATION RULES.

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

BIBLIOGRAPHY

Basic:

- Hoffman, J.D. Numerical methods for engineers and scientists. 2nd ed. rev. and exp. New York: Marcel Dekker, 1992. ISBN 0824704436.
- Chapra, S.C.; Canale, R.P. Métodos numéricos para ingenieros. 6a ed. México: McGraw Hill, 2011. ISBN 978-607-15-0499-9.
- Dahlquist, G.; Björck, A. Numerical Methods. Mineola: Dover, 2003. ISBN 0486428079.