ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

43000449 - Sustainable Environmental Geotechnics For Green Cities

DEGREE PROGRAMME

04AM - Master Universitario Ingenieria De Estructuras, Cimentaciones Y Materiales

ACADEMIC YEAR & SEMESTER

2025/26 - Semester 2

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Learning guide

1. Description

1.1. Subject details

Name of the subject	43000449 - Sustainable Environmental Geotechnics For Green Cities
No of credits	4.5 ECTS
Type	Optional/elective
Academic year ot the programme	First year
Semester of tuition	Semester 2
Tuition period	February-June
Tuition languages	English
Degree programme	04AM - Master Universitario Ingenieria de Estructuras, Cimentaciones y Materiales
Centre	04 - E.T.S. De Ing. De Caminos Canales Y P.
Academic year	2025-26

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Ruben Angel Galindo Aires	Lab Geotecnia	rubenangel.galindo@upm.es	W - 11:00 - 13:00
Ignacio Gonzalez Tejada	Lab. Geotecnia	ignacio.gtejada@upm.es	M - 11:00 - 13:00
Luis Jorda Bordehore (Subject coordinator)	Lab. Geotecnia	l.jorda@upm.es	Tu - 11:00 - 13:00
Sara Martinez Delgado		s.martinezd@upm.es	Tu - 11:00 - 13:00

* The tutoring schedule is indicative and subject to possible changes. Please check tutoring times with the faculty member in charge.

3. Prior knowledge recommended to take the subject

3.1. Recommended (passed) subjects

- Cimentaciones Especiales

3.2. Other recommended learning outcomes

- Soil Mechanics

- Foundation Engineering

- Rock Mechanics

- Geotechnics

4. Skills and learning outcomes *

4.1. Skills to be learned

CB10 - Que los estudiantes posean las habilidades de aprendizaje que les permitan continuar estudiando de un modo que habrá de ser en gran medida autodirigido o autónomo.

CT3 - Compromiso y capacidad de aplicación de los estándares de deontología en investigación y ejercicio profesional avanzado

4.2. Learning outcomes

RA76 - Understanding on th complex phenomena associated with the multifunctional operation of energy geostructures that need to be considered in analysis and design

RA77 - Understanding on the geomechanics and coupling with underground water flow, thermal, chemical fields

RA82 - Undertanding on environmental assessment techniques and its application in geotechnical engineering (Life Cycle Assessment, Carbon and Hydric footprints, etc.)

RA81 - Understanding on the opportunities of energy geostructures and underground living for green cities

RA78 - Understanding on the more relevant and geotechnical aspects of landfills (slope stability, settlement, evolution, etc.)

RA80 - Understanding on the most relevant aspects in the design of underground living structures

RA79 - Understanding on how pollutants are transported in soils, the definition of pollution in soils, remediation techniques and soil improvement methods

* The Learning Guides should reflect the Skills and Learning Outcomes in the same way as indicated in the Degree Verification Memory. For this reason, they have not been translated into English and appear in Spanish.

5. Brief description of the subject and syllabus

5.1. Brief description of the subject

Current societal challenges present environmental geotechnics as an opportunity to reinforce the need for a change in paradigm towards greener cities. This course concentrates on several thematic areas where sustainability solutions with a relevant geotechnical core may be particularly interesting in the case urban areas. More precisely, two topics are particularly addressed in the course: Energy geostructures (this is, the thermo-activation of foundations, tunnel linings and earth retaining structures to exchange heat with the soil and for waste heat recovery) and structures for underground living (this is the use of natural or human-made caves or structures to minimize the environmental impact and to benefit from noise reduction, constant temperature and security). Other topics also addressed in the course include the re-use of construction and demolition of wastes, industrial wastes and marine sediments as earthfills, the management of municipal solid waste (geotechnics of landfills), the remediation of contaminated soils and the prevention and mitigation of pollutant transport in soils. The course presents the state-of-the-art as well as the most widely established methods for the design and calculation of the above mentioned technologies.

Challenge-based learning is applied for the topic of energy geostructues. Real cases of thermoactivation will be used as case studies.

5.2. Syllabus

1. Energy geostructures (thermo-active foundations) Challenge based learning approach
    1.1. Energy and geotechnics, overview of energy geostructures
    1.2. Heat and mass transfer and deformation in the context of energy geostructures
    1.3. Observations: Thermohydromechanical behavior of soils, soil-structure interfaces, single energy piles and pile groups
    1.4. Anlytical modeling of steady and transient heat transfer
    1.5. Analytical modeling of capacity and deformation of single energy piles and pile groups
    1.6. Numerical modeling of energy geostructures
    1.7. Design of energy geostructures
    1.8. Construction aspects
2. Underground living
    2.1. Overview of underground living: Historical and geographical distribution (worldwide, Mediterranean-wide)diterranean)
    2.2. Underground environmental and geo-climatic advantages
    2.3. Stability and geotechnics of caves
    2.4. Avant-garde underground architecture and modern trends
3. Landfill geotechnics
    3.1. Overvierw of landfills (historic evolution, relevant aspects for the design of the landfill and its closure))
    3.2. Geotechnical properties of waste and evolution
    3.3. Slope stability
4. Pollution in soils
    4.1. Definition of polluted soils, historical overview and legislation
    4.2. Transport of pollutants in soils (fundamentals and modeling)
    4.3. Geobarriers
    4.4. Remediation and soil improvemtent
5. Sustainability Assessment

5.1. Life Cycle Assessment

5.2. Carbon and hydric footprint in geotechnical engineering

6. Schedule

6.1. Subject schedule*

Week	Type 1 activities	Type 2 activities	Distant / On-line	Assessment activities
1	**Topic 1** Duration: 03:00 Lecture			
2	**Topic 1** Duration: 03:00 Problem-solving class			
3	**Topic 1** Duration: 03:00 Problem-solving class			
4	**Topic 1** Duration: 03:00 Problem-solving class			
5	**Topic 1** Duration: 03:00 Problem-solving class			
6	**Topic 2** Duration: 03:00 Lecture			
7	**Topic 2** Duration: 03:00 Problem-solving class			
8	**Topic 2** Duration: 03:00 Problem-solving class			
9	**Topic 2** Duration: 03:00 Problem-solving class			
10	**Topic 2** Duration: 03:00 Problem-solving class			**Challenge-based approach (team work)** Group work Progressive assessment Presential Duration: 01:00
11	**Topic 3** Duration: 03:00 Lecture			
12	**Topic 3** Duration: 00:00 Problem-solving class			
13	**Topic 4** Duration: 03:00 Lecture			

14	**Tema 4** Duration: 03:00 Problem-solving class			**Cave study case** Group presentation Progressive assessment Presential Duration: 01:00
15	**Topic 5** Duration: 03:00 Lecture			
16	**Topic 5** Duration: 00:00 Cooperative activities			**Individual work** Individual work Progressive assessment Presential Duration: 01:00
17				**Examen Final** Written test Global examination Not Presential Duration: 00:00

Depending on the programme study plan, total values will be calculated according to the ECTS credit unit as 26/27 hours of student face-to-face contact and independent study time.

7. Activities and assessment criteria

7.1. Assessment activities

7.1.1. Assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
10	Challenge-based approach (team work)	Group work	Face-to-face	01:00	40%	5 / 10	CB10 CT3
14	Cave study case	Group presentation	Face-to-face	01:00	40%	5 / 10	CB10 CT3
16	Individual work	Individual work	Face-to-face	01:00	20%	5 / 10	CB10 CT3

7.1.2. Global examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
17	Examen Final	Written test	No Presential	00:00	100%	5 / 10	CT3 CB10

7.1.3. Referred (re-sit) examination

No se ha definido la evaluación extraordinaria.

7.2. Assessment criteria

?Continuous assessment:

o Practical tests and exercises (40% underground living and 20% sustainability), which may include short dissertations, presentations, homework exercises (requiring the use of both numerical and analytical tools) and written test. The number, kind and weight of the tests will be detailed at the beginning of the course and will be adapted to the number and background of the students enrolled.

o Challenge-Based approach (40%): team work assessing the geothermal resource and the soil-structure interaction in a real case of thermoactive structure provided by an external stakeholder

Final weigthed score must be over 5 on a scale of 0 to 10.

Final exam: Written test, scored from 0 to 10. A minimum score of 5 is necessary.

8. Teaching resources

8.1. Teaching resources for the subject

Name	Type	Notes
Analysis and Design of Energy Geostructures, Laloui y Rotta Loria	Bibliography	
CFMS-SYNTEC-SOFFONS-FNTP, 2017. Recommandations pour la conception, le dimensionnement et la mise en úuvre des géostructures thermiques. Rev. Franç. Géotech. 149, 120.	Bibliography	
SIA-D0190, 2005. Utilisation de la Chaleur du Sol par des Ouvrages de Fondation et de Soutènement en Béton. Guide pour la Conception, la Realisation et la Maintenance, Zurich, Switzerland.	Bibliography	
Environmental Geotechnics, Robert Sarby	Bibliography	

9. Other information

9.1. Other information about the subject

This course addresses the UN's SDGs 7, 11 and 13

La asignatura se relaciona con el ODS7, el ODS11 y el ODS 13

Challenge-based learning is done in the framework of EELISA European University.