Course guide
2500203 - GECSISTERR - Earth System

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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:** Catalan, Spanish

LECTURER

Coordinating lecturer: JOSE MOYA SANCHEZ

Others: MARC BERENGUER FERRER, JOSE MOYA SANCHEZ

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
14445. Recognize the biological bases and foundations of the plant and animal field in engineering: notions of genetics, biochemistry and metabolism, physiology, organisms and environment, population dynamics, flows of matter and energy and changes in ecosystems, biodiversity, principles of the kinetics of microbial growth and reactor theory.
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.
14449. Apply the basic principles of general chemistry, organic and inorganic chemistry and their applications in engineering.
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.

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.

TEACHING METHODOLOGY

The subject consists of the following activities at the classromm:
1) Theory sessions that include expository theory classes and theory quiz discussion workshops (30h).
2) Problem's sessions (14 h) and problem solving workshops (3.5 h).
3) Real case study workshops (2 hours).
4) Tutoring and presentation of group work on a real case (6 h).
5) Evaluation (exams): 4 h.

There are specific optional sessions to resolve and discuss the exams.

Detailed support material and the schedule of the subject is provided on the ATENEA Virtual Campus.

LEARNING OBJECTIVES OF THE SUBJECT

Our planet is a complex system comprised of various very dynamic subsystems (lithosphere, hydrosphere, atmosphere, cryosphere, biosphere and anthroposphere) that interact varyingly and intensely at different time scales. A basic description of the internal dynamics of each subsystem is added, along with their interactions to assure an overview of the global functioning of our planet and climate.

1. Have a global vision of the dynamics of our planet and its subsystems: composition and structure of the lithosphere, of the hydrosphere, from the atmosphere, the cryosphere and the biosphere.
2. Understand the transfer of mass and energy: a) in each subsystem (atmospheric circulation, ocean circulation, continental hydrology, tectonics plates, sediment transport, nutrient transfer); b) among them (water cycle, rock cycle, biogeochemical cycles); and c) of
global balances.
3. Understand global climate, regional climates, and the factors that control them. Knowledge of: a) the climatic changes that occurred during the Quaternary at various time scales and current climate change, b) the causes of these changes and their consequences on subsystems terrestrial, and c) the influence of human activity on current climate change.

Earth System. Our planet is a complex macrosystem made up of several highly dynamic systems (lithosphere, hydrosphere, atmosphere, cryosphere, biosphere, and anthroposphere) that interact intensely and in a changing way at different time scales. A basic description of each of the subsystems and their internal dynamics is provided, as well as an overview to understand the global functioning of the planet and the climate.

Our planet is a complex system made up of several highly dynamic subsystems (lithosphere, hydrosphere, atmosphere, cryosphere, biosphere and anthroposphere) that interact intensively and in a changing way at different time scales. A basic description of the internal dynamics of each of the subsystems as well as their interactions is given to achieve an overall view of the global functioning of our planet and the climate.

1. Have a global view of the dynamics of our planet and the subsystems that make it up: composition and structure of the lithosphere, the hydrosphere, the atmosphere, the cryosphere and the biosphere.

2. Understand the transfer of mass and energy: a) in each subsystem (atmospheric circulation, oceanic circulation, continental hydrology, plate tectonics, sediment transport, nutrient transfer); b) between them (water cycle, rock cycle, biogeochemical cycles); and c) of the global balance sheets.

3. Understand global climate, regional climates and the factors that control them. Knowledge of: a) the climate changes that occurred during the Quaternary at various time scales and current climate change, b) the causes of these changes and their consequences on terrestrial subsystems, and c) the influence of the activity human in current climate change.

STUDY LOAD

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

Total learning time: 150 h

CONTENTS

Section I: Introduction to the global dynamics of Earth

Description:
Components of the Earth System. Global matter transfer and introduction to global biogeochemical cycles. Energy on Earth: energy sources, transfer and global energy balance. Basic comparison with the global dynamics of other planetary bodies in the Solar System.
Assessment of: 1) the thermal energy and the effective temperatura of the planets of the Solar System; 2) the energy budget of Earth at three levels of the atmosfere.

Specific objectives:
- Provide a first global view of the dynamics of our planet and its subsystems. Show the basic differences with the dynamics of other planets in the Solar System.
- Understanding the basic thermal dynamics of planets.
- Learn to calculate energy balance on a global scale and at different heights.

Full-or-part-time: 9h 36m
Theory classes: 2h
Practical classes: 2h
Self study : 5h 36m

Section II: Internal dynamics of terrestrial subsystems

Description:
- Composition and structure of the lithosphere and crust. Internal geodynamics and plate tectonics. Volcanism and seismicity. The internal cycle of rocks and lithosphere formation.
- Composition and discontinuities in the core and mantle. Convection currents (transfer of matter and heat). The geomagnetic field and its importance for the atmosphere, biosphere and human activity.
Composition and stratification of the atmosphere. Global atmospheric circulation. Atmospheric dynamics. Regional winds.
Composition and structure of the oceans. Ocean circulation, surface currents and deep currents, global currents and regional currents. Global ocean biogeochemistry.
Problems on mass and energy flow 2: Flows in continental areas
Stationary mass balance problems
Problem solving workshop for sessions 1and 2
The water cycle on the continents. The river environment. The lake environment. The underground hydrosphere.
Problem session 4. Hydrological balance in river basins
Workshop to solve the problems of sessions 3 and 4
Glaciers: type and movement. Ice and climate balance. Causes of the existence of ice sheets. Permafrost.

Specific objectives:
- Understanding the composition, structure, formation and movements on a global scale of the lithosphere subsystem, the mantle and the core of the Earth.
- Knowledge and understanding of the composition, structure and global circulation in the subsystem atmosphere.
- Knowledge and understanding of the oceanic branch of the hydrosphere subsystem. Composition, structure and global circulation in the oceans.
- Understanding of external geodynamics in emerging continental areas.
- Knowledge and understanding of the continental branch of the hydrosphere subsystem. Water cycle in emerging areas and related geomorphological processes.
- Understanding of a basic hydrological balance
- Knowledge and understanding of the set of glaciers as an essential and special part of the hydrosphere subsystem, particularly important during the last 2.6 million years on Earth.

Full-or-part-time: 45h 36m
Theory classes: 11h
Practical classes: 6h
Laboratory classes: 2h
Self study : 26h 36m

Section III: Interaction of natural terrestrial subsystems

Description:
Atmosphere-hydrosphere interactions: interaction on the continental areas and on oceanic areas. Influence of other natural subsystems on the global climate: influence of the morphology of the terrestrial solid surface, influence of the cryosphere, influence of the biosphere. Climates and climatic zones.
Description and analysis of the causes and consequences of the storm Gloria in Catalonia.
There are two tutoring sessions for the bibliographic work. The first is about the search, selection and synthesis of information (0.5 h) and is done shortly after the start of the course. The second is about the oral communication of results and to raise doubts (2 h) and is done one month before the presentation of the work.
The external cycle of rocks. Weathering of rocks: physical-chemical and biological processes. Soil soils: introductory concepts (concept, classification, training and importance for life). General processes of transport and deposition of sediments on the continents (colluvial, fluvial, lacustrine, glacial and wind). External geodynamical processes at the sea and ocean floor.
Practice of recognizing landforms and their temporal evolution using Google Earth.
Coastal environments: general circulation of currents (waves and tides) and sediments on the coast, type of sedimentary environments. Shallow coastal and marine ecosystems. Local changes in sea level (tectono-eustatic changes and subsidence in deltas and estuaries).
Problem session 6. 4D recognition of landforms: fluvial and coastal landforms
Problem solving workshop for sessions 5 and 6.
Macronutrients and micronutrients. Water cycle, carbon cycle, sulfur cycle, phosphorus cycle, nitrogen cycle, oxygen cycle, iron cycle, carbonate cycle, silica cycle. Interconnection of cycles.
Tutoring 2 of the thematic work
Example of non-stationary mass balance

Specific objectives:
- Identify the main characteristics of the climate system.
- Characterize the transfer of mass and energy between the atmosphere, the hydrosphere (fluid and solid), the solid surface of the Earth and the biosphere.
- Understand the climatic zonation of the planet and its relationship with the orbital parameters of the Earth.
- Understanding a type of extreme hydrometeorologic event and their consequences.
- Training in transversal competence of autonomous search for information.
- Training in transversal oral communication competence.
- Identify and characterize the external geodynamics of the Earth (interaction with the lithosphere of other subsystems of the Earth).
- Identify soils and, in particular, the pedogenic soils such as the skin of the solid Earth.

- Identify landforms and the domain of different geomorfological processes with a free visual tool.
- Identify shallow coastal and marine areas as those with the greatest joint interaction between the subsystems of our planet.
- Understand the concept of a biogeochemical cycle on a global scale.
- Characterize the main cycles, their interdependence and their relationships with the interaction of the Earth's subsystems.

Full-or-part-time: 64h 48m
Theory classes: 15h
Practical classes: 6h
Laboratory classes: 6h
Self study : 37h 48m

Section IV: Global dynamics of Earth, temporal evolution and interaction with the anthroposphere.

Description:
Palaeogeography of the continents. Evolution of the atmosphere and the ocean. Global climate changes. Global sea level changes.
Evolution of the Earth during the Quaternary and Holocene.
Problem solving workshop for session 7
Climate change and the history of civilizations.
Three sessions of 1.5 hours each.

Specific objectives:
- Know and understand the temporal evolution of the Earth on a geological scale and, particularly, in the last 2.6 million years, as example of the global changes in the system and of the interactions between the subsystems of our planet.
- Know and understand natural climate changes, their causes and their consequences.

- Inform and discuss the influence of climate on history.

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

GRADING SYSTEM

The assessment includes:

1) Two partial theory and problem exams, each with a weight of 37% of the subject's grade.

2) Deliverables and tests of the problem sessions, with a total weight of 14%.

3) Group delivery and oral presentation of the thematic work: weight 12%.

Grading criteria for "not presented":

a) In an assessment test (examination): the grade of "not presented" will be obtained in the exam if the grade obtained is equal to or less than 1.5 and if the 'exam is taken before 20% of the time of the duration provided for it has passed.

b) In the subject: the delivery of any assessable activity is mandatory. In case of failure to hand in an exam, the thematic work or two or more classroom practices within the period indicated by the teaching staff, the student will obtain the qualification of 'not presented' in the subject.

Criteria for admission to the reassessment:

Students who have failed the regular assessment will have the option to take a reassessment test in the period set in the academic calendar, as long as: a) they have taken all the assessment tests of the subject, and b) have obtained a grade higher than 2.5 in the ordinary assessment.

Students who have already passed or students classified as not present will not be able to take the revaluation test of a subject. The maximum grade in the case of taking the reassessment exam will be five (5.0).

The non-attendance of a student called to the re-evaluation test, held in the fixed period, cannot give rise to the completion of another test with a later date. Extraordinary assessments will be carried out for those students who, due to accredited major reason (e.g. disease accredited by an official physicist certificate) have not been able to take any of the assessment tests. These tests must be authorized by the corresponding head of studies, at the request of the teacher responsible for the subject, and will be carried out within the corresponding teaching period.

EXAMINATION RULES.

Practice sessions are held in medium-size groups. Each week the schedule of the practice group alternates so that the same group does not always have the last hour of the afternoon. The practice schedule for each group is indicated in the subject calendar that is published at the beginning of the semester in Atenea.

It is mandatory to respect the schedule of the practice group. Access to the classroom will not be allowed outside the hours of the assigned practice group. If you do not show up for a practice at the assigned time, it will be classified as "no show".

BIBLIOGRAPHY

Basic:
- Jacobson, M.C.; Charlson, R.J.; Rodhe, H.; Orians, G.H. Earth system science: from biogeochemical cycles to global change [on line]. San Diego (Calif.): Academic Press, 2000 [Consultation: 08/02/2021]. Available on: https://www.sciencedirect.com/bookseries/international-geophysics/vol/72/suppl/C. ISBN 9780080530642.
- Lenton, Tim. Earth system science: a very short introduction. New York: Oxford University Press, 2016. ISBN 9780198718871.
- Strahler, A.N.; Strahler, H.S. Geografía física. Barcelona: Omega, 1989. ISBN 8428208476.
- Siever R. et al. "Dinamismo terrestre". Investigación y ciencia. num 86 (1983).

Complementary:
- Katzenstein, Larry. "Our ever changing Earth". Scientific American [on line]. Volume 15, number 2 (1985) [Consultation: 20/12/2023]. Available on: https://geocryology.files.wordpress.com/2014/03/scientific-american-special-edition-changing-earth_.pdf.- "La superficie terrestre". Investigación y ciencia. Temas 20.