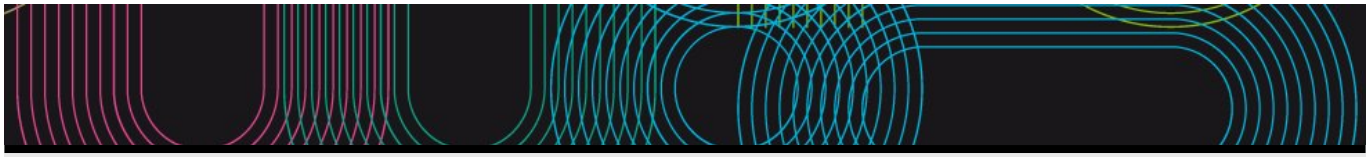

IDENTIFYING DATA				
Underground works				
Subject	Underground works			
Code	V09G311V01315			
Study programme	Grado en Ingeniería de los Recursos Mineros y Energéticos			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	2nd
Teaching language	#EnglishFriendly Spanish			
Department				
Coordinator	Pozo Antonio, José Santiago			
Lecturers	Alejano Monge, Leandro Rafael González Fernández, Manuel Alejandro Pozo Antonio, José Santiago			
E-mail	ipozo@uvigo.es			
Web	http://moovi.uvigo.gal/			
General description	In this subject, the basis for the characterization of the terrain, design and execution of underground works are laid, paying special attention to tunnels. Subject of the English Friendly program: International students may request from the teaching staff: a) materials and bibliographical references for the follow-up of the subject in English, b) attend tutorials in English, c) tests and evaluations in English.			

Training and Learning Results	
Code	
B1	Scientific and technical training and qualification as a Mining Engineer and knowledge of the functions of consultancy, analysis, design, calculus, project, construction, maintenance, preservation and exploitation.
B2	To be familiar with the multiple technical and legal factors involved in the process of development, within the field of mining engineering, with the knowledge acquired in accordance with section 5 of order CIN/306/2009, pertaining to geological and mining prospecting and investigation, the explorations of all sorts of geological resources, including groundwater, underground construction, underground storage, treatment and benefit plants, energy plants, mineral processing and steel and iron plants, building materials plants, carbon chemistry, petrochemistry and gas plants, waste treatment and tributary plants, explosives factories, and ability to use well-tested methods and accredited technologies, with the aim of achieving the highest efficiency and ensuring the protection of the Environment and the safety and health of workers and users.
B3	Ability to design, write and plan partial or specific projects within the units specified in the previous section, such as mechanical and electric plants and their maintenance, networks of energy transportation, facilities for transportation and storage of solid, liquid and gaseous materials, waste sites, tailing dams, foundation and support, demolition, restoration, controlled explosions and explosives logistics.
B4	Ability to design, plan, run, inspect, sign and manage projects, plants or facilities, within their field.
B6	Ability to maintain, preserve and exploit projects, plants and facilities, within their field.
B7	Ability to do, within the field of mining engineering, with the knowledge acquired in accordance with section 5 of order CIN/306/2009, measurements, stakeouts, planes and maps, calculations, assessments, risk analyses, expert reports and studies, work plans, environmental and social impact studies, restoration plans, quality control systems, prevention systems, analysis and assessment of the properties of metal, ceramic, refractory, synthetic and other materials, soil and rock mass classification and other works of a similar kind.
B8	To be familiar with and ability to apply the relevant legal framework to practice professionally as a Mining Engineer.
C24	To know, understand and use the principles of design and execution of surface and underground projects.
C25	To know, understand and use the principles of perforation and support techniques used in underground and surface works.
D1	Ability to draw links between the different elements of all the knowledge they acquired, understanding them as components of a body of knowledge with a clear structure and strong internal cohesion.

D2	Ability to develop a project to completion in any field of this branch of engineering, combining appropriately the knowledge acquired, consulting the relevant sources of information, carrying out any required inquiries, and joining interdisciplinary work teams.
D3	To suggest and develop practical solutions, using the relevant theoretical knowledge, to phenomena and problems-situations of ordinary reality that are specific to engineering, developing appropriate strategies.
D5	To be familiar with the relevant sources of information, including constant updating, in order to practice one□s profession competently, accessing all the present and future tools of information search, constantly adapting to technological and social changes.
D7	Ability to organize, understand, assimilate, produce and handle all the relevant information to develop their professional work, using appropriate computing, mathematical, physics tools, etc. when these are required.
D9	Understanding the importance of safety issues and being able to foster awareness about safety among people within their environment.

Expected results from this subject

Expected results from this subject	Training and Learning Results		
Knowledge integration of the different disciplines that converge in this matter.	B1 B3 B4 B6 B7	C24 C25	D1 D2 D3 D5 D7
Understanding of the basic technology and safety aspects in the subterranean work.	B1 B2 B3 B4 B6 B7 B8	C24 C25	D7 D9
Knowledge of the documents that have to integrate the project of an underground work and its contents.	B1 B2 B3 B4 B6 B7	C24 C25	D2 D3
Knowledge and application of the theoretical-experimental processes used in the characterisation of the terrain, in the design of the work and in the selection of the execution methods.	B1 B2 B3 B4 B6 B7	C24 C25	D1 D2 D7
Knowledge and application of techniques to estimate the performances of the execution methods of tunnels.	B1 B2 B3 B4 B6 B7 B8	C24 C25	D1 D2 D3 D5 D7
The application of design principles of blastings.	B1 B3 B6 B7 B8	C24 C25	D2 D3 D7
Knowledge of the fundamental principles of safety during the construction of a underground work.	B1 B2 B3 B4 B7 B8	C24 C25	D2 D3 D9

Contents

Topic	
The design of underground works.	Introduction Applications of underground works

Ground characterization	Characterization of rock masses in the field Mechanical behavior of the rocks Characterization and behavior of discontinuities Properties of the rock massif (Geometric Classifications) Natural tensions of the ground
Holding technology	Metal frames. Description and operation of rigid and articulated metal frames. Description, operation and placement of the sliding frames. Holding technologies. Elements of a holding system. Systems of adhesion holding- (cement, resin). Friction holding systems (punctual and distributed). Valuation of the suitability of the ballooning in different conditions. Use of gunite and projected concrete. Use in mining. Characteristic parameters of the concrete. Components of the projected concrete and dosages. Placement: Gunite in dry and wet way.
Undeground work design. Holding system.	General formulation of the excavation problem. Design based on geomecanic classifications. Analysis of tensions in rock masses Convergence convergence method Analysis of the stability of wedges in excavations New Austrian Method
Ground technologies	Injections Grouting Ground freezing
Classification of the ground following its mechanical excavability level.	Excavation, perforability and blasting rates
Tunnels desing technologies	Roadheader TBMs (Topos and shields) Advance drilling and blasting (Jumbos) Mechancial precut Traditional methods
Safety into underground works during construction	Basic aspects Legislation Appearances applied

Planning			
	Class hours	Hours outside the classroom	Total hours
Lecturing	12	30	42
Problem solving	12	29.5	41.5
Laboratory practical	8	15	23
Mentored work	4	20	24
Studies excursion	5	0	5
Seminars	4	0	4
Flipped Learning	5	3	8
Essay questions exam	2.5	0	2.5
*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.			

Methodologies	
	Description
Lecturing	Description of the basic theories of application.
Problem solving	Manual resolution of problems.
Laboratory practical	Practice of problems resolution and creation of stable designs with programs type DIPS, ROCLAB, UNWEDGE and ROC-SUPPORT. Also it will visit the laboratory of rock mechanics, where the operation of the different tests for characterisation will be carried out.
Mentored work	Approach and presentation of real problems by groups. Analysis and discussion.
Studies excursion	A visit to an undergroud work, in the case of available finance.
Seminars	Comments of real cases, as well as of errors committed in the past.
Flipped Learning	Previous reading of scientific articles and of press to work in the classroom

Personalized assistance	
Methodologies	**Description**

Problem solving	Be close to the students to advise on works, forms of calculation, and make them think about the impact of the real ground and the variability of the data in the final design and the behavior of the work throughout his operational life. For all teaching modalities, the tutoring sessions may be carried out by electronic means (email, videoconference, Moovi forums, ...) under the modality of prior agreement.
Laboratory practical	Be close to the students to advise on works, forms of calculation, and make them think about the impact of the real ground and the variability of the data in the final design and the behavior of the work throughout his operational life. For all teaching modalities, the tutoring sessions may be carried out by electronic means (email, videoconference, Moovi forums, ...) under the modality of prior agreement.
Mentored work	Be close to the students to advise on works, forms of calculation, and make them think about the impact of the real ground and the variability of the data in the final design and the behavior of the work throughout his operational life. For all teaching modalities, the tutoring sessions may be carried out by electronic means (email, videoconference, Moovi forums, ...) under the modality of prior agreement.
Studies excursion	Be close to the students to advise on works, forms of calculation, and make them think about the impact of the real ground and the variability of the data in the final design and the behavior of the work throughout his operational life. For all teaching modalities, the tutoring sessions may be carried out by electronic means (email, videoconference, Moovi forums, ...) under the modality of prior agreement.
Seminars	Be close to the students to advise on works, forms of calculation, and make them think about the impact of the real ground and the variability of the data in the final design and the behavior of the work throughout his operational life. For all teaching modalities, the tutoring sessions may be carried out by electronic means (email, videoconference, Moovi forums, ...) under the modality of prior agreement.
Flipped Learning	Be close to the students to advise on works, forms of calculation, and make them think about the impact of the real ground and the variability of the data in the final design and the behavior of the work throughout his operational life. For all teaching modalities, the tutoring sessions may be carried out by electronic means (email, videoconference, Moovi forums, ...) under the modality of prior agreement.

Assessment

	Description	Qualification	Training and Learning Results		
Lecturing	Written exam of short answer questions to analyze the understanding of the theoretical-practical content seen during the course. Learning outcomes: Knowledge integration of the different disciplines that converge in this matter. Understanding of the basic technology and safety aspects in the subterranean work Knowledge of the documents that have to integrate the project of an underground work and its contents. Knowledge and application of the theoretical-experimental processes used in the characterisation of the terrain, in the design of the work and in the selection of the execution methods. Knowledge and application of techniques to estimate the performances of the execution methods of tunnels. The application of design principles of blastings. Knowledge of the fundamental principles of safety during the construction of a underground work.	35	B1 B2 B3 B4 B7 B8	C24 C25	D1 D3 D7 D9
Problem solving	Written tests consisting of the solving of problems covering the concepts studied during the course. Engineers should know how to solve real problems, so the resolution of these exercises is the most valued part of the assessment. Learning outcomes: Knowledge integration of the different disciplines that converge in this matter. Knowledge and application of the theoretical-experimental processes used in the characterisation of the terrain, in the design of the work and in the selection of the execution methods. Knowledge and application of techniques to estimate the performances of the execution methods of tunnels.	35	B1 B2 B3 B4 B6 B7 B8	C24 C25	D1 D2 D3 D7 D9

Laboratory practical	Evaluation through the report- practices and exposure in class real cases. Learning outcomes: Knowledge integration of the different disciplines that converge in this matter. Knowledge and application of the theoretical-experimental processes used in the characterisation of the terrain, in the design of the work and in the selection of the execution methods. Knowledge and application of techniques to estimate the performances of the execution methods of tunnels. Knowledge of the fundamental principles of safety during the construction of a underground work.	10	B1 B2 B3 B4 B6 B7 B8	C24 C25	D1 D2 D3 D5 D7
Mentored work	Formulation and oral presentation, by groups, of a topic related to the subject. Analysis and discussion. Learning outcomes: Knowledge integration of the different disciplines that converge in this matter. Understanding of the basic technology and safety aspects in the subterranean work Knowledge of the documents that have to integrate the project of an underground work and its contents. Knowledge and application of the theoretical-experimental processes used in the characterisation of the terrain, in the design of the work and in the selection of the execution methods. Knowledge and application of techniques to estimate the performances of the execution methods of tunnels. The application of design principles of blastings. Knowledge of the fundamental principles of safety during the construction of a underground work.	20	B1 B2 B3 B4 B6 B7 B8	C24 C25	D1 D2 D3 D5 D7 D9

Other comments on the Evaluation

Once the semester has started, the student will have one month to notify about his/her decision to renounce the continuous assessment system and use the overall assessment to the coordinator of the subject.

Continuous evaluation, first opportunity:

Before the official date of the exam in the first opportunity, the qualification of each student will result from the sum of the First Partial (35%) + Second Partial (35%) + Oral Presentation (20%) + Practice Report (10%). Each partial will have two parts: one of theory and another of problems. In each part the student must obtain a minimum grade of 3.5/10 both in theory and in problems. If the minimums are not obtained, the qualification for that partial will correspond to the minimum grade obtained. The student who does not obtain more than 4/10 in the partials must take the part corresponding to said partial in the official exam.

It is important to emphasize that the practices are not mandatory, but the student may present the report in any way, and it will be evaluated.

If the student does not pass any of the partial exams (with a minimum grade of 4/10), he/she must take its corresponding part of the final exam on the official date of the first opportunity. In this case, the exam will have a weight in the final grade of 35% (if a partial was failed) or 70% (if neither of the two partials were failed). As previously indicated, in the final exam, in theory and in the problems of the parts equivalent to each part, the student must obtain a minimum grade of 3.5/10. If the minimums are not obtained, the qualification for that part equivalent to a partial will be the minimum grade obtained in theory or problems. The rest of the activities continue to have the same weight as those indicated above: Oral presentation (20%) + Practice report (10%). This sum will be done if the average of the two partials or of the equivalent parts in the official exam is greater than 4/10.

Continuous evaluation, second chance:

The student will have the possibility to do an exam with a weight of 100% of the final grade for the subject. In this case, the student must obtain at least a 4/10 in both theory and problems. If the minimums are not obtained, the grade corresponds to the minimum grade obtained. The exam will be approved with a mark of 5/10.

General evaluation:

Students who choose not to participate in the continuous assessment system may take the final exam for the subject on the official dates, with this exam weighing 100% of the final grade. In each of them the student must obtain a minimum grade of 4/10 both in theory and in problems. If the minimums are not obtained, the final grade of the exam corresponds to the minimum grade obtained. The exam will be approved with a mark of 5/10.

Exam calendar. Verify / check updated form on the web page of the center:

http://minaseenerxia.uvigo.es/es/docencia/examenes

Sources of information

Basic Bibliography

Brady, B. and Brown, E.T., **Rock Mechanics for Underground Mining**, 1º, Springer, 2004

Hoek, E. and Brown, E.T.,, **Underground Excavations in Rock**, 1º, CRC Press, 1980

Hudson, J.A. and Harrison, J.P., **Engineering Rock Mechanics. Illustrative Worked Examples**, 1º, Elsevier Science, 2011

Complementary Bibliography

Amadei, B and Stephansson, O., **Rock Stress and its Measurement**, 1º, Springer, 1997

Brown, E.T., **Rock Characterization Testing and Monitoring**, 1º, Pergamon Press, 1981

Hoek, E., Kaiser,P.K. and Bawden.W.F., **Support of Underground excavations in Hard Rock**, 1º, CRC Press, 2000

Hudson, J.A., **Comprehensive Rock Engineering. Principles, Practice and Projects,**, 1º, Pergamon, 1993

Recommendations

Subjects that are recommended to be taken simultaneously

Sustainable exploitation of mining resources II/V09G311V01308
Construction management and on-site layout/V09G311V01306

Subjects that it is recommended to have taken before

Geology: Geology/V09G311V01206
Materials resistance/V09G311V01203
Sustainable exploitation of mining resources I/V09G311V01302
Rock mechanics/V09G311V01304
Soil mechanics/V09G311V01301
Blasting/V09G311V01303