



POLITÉCNICA

INTERNATIONAL
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COORDINATION PROCESS OF
LEARNING ACTIVITIES
PR/CL/001



E.T.S. de Ingenieros de Minas y
Energía

ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

63000274 - Advanced Explosives Engineering

DEGREE PROGRAMME

06AK - Master Universitario En Minería Sostenible

ACADEMIC YEAR & SEMESTER

2024/25 - Semester 1

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1. Description

1.1. Subject details

Name of the subject	63000274 - Advanced Explosives Engineering
No of credits	4 ECTS
Type	Compulsory
Academic year of the programme	First year
Semester of tuition	Semester 1
Tuition period	September-January
Tuition languages	English
Degree programme	06AK - Master Universitario en Minería Sostenible
Centre	06 - Escuela Técnica Superior De Ingenieros De Minas Y Energía
Academic year	2024-25

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Pablo Segarra Catusus	625	pablo.segarra@upm.es	M - 09:00 - 11:00 Tu - 16:00 - 18:00 Th - 09:00 - 11:00
Jose Angel Sanchidrian Blanco (Subject coordinator)	616	ja.sanchidrian@upm.es	F - 09:00 - 15:00
Lina Maria Lopez Sanchez	622	lina.lopez@upm.es	Tu - 08:30 - 10:00 W - 08:30 - 10:00 Th - 08:30 - 10:00 F - 08:30 - 10:00

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

member in charge.

2.2. Research assistants

Name and surname	Email	Faculty member in charge
Gomez Mateos, Santiago	santiago.gomez@upm.es	Sanchidrian Blanco, Jose Angel

3. Prior knowledge recommended to take the subject

3.1. Recommended (passed) subjects

The subject - recommended (passed), are not defined.

3.2. Other recommended learning outcomes

- Basic knowledge of explosives and initiation systems / Conocimientos básicos de los explosivos y sistemas de iniciación
- Basic knowledge of blast design / Conocimientos básicos de diseño de voladuras
- Basic knowledge of rock mechanics / Conocimientos básicos de mecánica de rocas
- Basic knowledge of mining / Conocimientos básicos de explotación de minas

4. Skills and learning outcomes *

4.1. Skills to be learned

CE15 - Aplicar los modelos de fragmentación y arranque de roca para el diseño avanzado de voladuras, su control, monitorización, minimización de efectos medioambientales y optimización económica dentro del contexto global de la operación / To apply fragmentation and rock excavation by blasting models for blast design, control, monitoring, minimization of environmental affections, and economical optimization in a mining operation context

CG1 - Aplicar conocimientos de ciencias y tecnologías avanzadas a la práctica profesional o investigadora de la Ingeniería Minera / To apply knowledge in advanced science and technology to the professional or research practice of Mining Engineering

CG2 - Poseer capacidad para diseñar, desarrollar, implementar, gestionar y mejorar productos, sistemas y

procesos en los distintos ámbitos de la actividad minera, usando técnicas analíticas, computacionales o experimentales avanzadas / To be able to design, develop, implement, manage and improve products, systems, and processes in different environments of the mining activity, using advanced analytic, computational or experimental techniques

CG3 - Comprender el impacto de la Ingeniería Minera y la extracción de recursos minerales y energéticos en el medio ambiente, el desarrollo sostenible de la sociedad y la importancia de trabajar en un entorno profesional y responsable / To understand the impact that Mining of mineral and energetic resources has on the environment, the sustainable development of society and the importance of working in a professional and responsible environment

CG4 - Capacidad de trabajar en un contexto internacional y en entornos complejos, multidisciplinares y bilingües (inglés-español) / Capacity to learn in an international context and complex environments, multidisciplinary and bilingual (English-Spanish)

CG5 - Creatividad / Creativity

4.2. Learning outcomes

RA16 - To apply rock fragmentation models from blasting and the available technologies for blast design, modeling and control / Aplicar los modelos de fragmentación de roca por voladura y tecnologías disponibles para el diseño, modelización y control de voladuras

RA18 - To have broad knowledge of vibrations from blasting and air blast: models, control and mitigation / Alcanzar un conocimiento amplio sobre vibraciones por voladura y onda aérea: modelos, control y mitigación

RA17 - To understand and calculate damage to rock from blasting and ore dilution / ? Comprender y calcular el daño a la roca por la voladura y la dilución del mineral

RA19 - To have a basic knowledge of other environmental aspects: detonation gases and carbon footprint / ? Alcanzar un conocimiento básico de otros aspectos medioambientales: gases de detonación y huella de carbono

* 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

The course gives an in depth knowledge and expert design capabilities of the key aspects of explosive engineering related to optimization of mine blasting excavation operations. Elements of safety and environmental effects are studied. Extensive use is made of modeling tools.

La asignatura profundiza en el conocimiento avanzado y capacidades de diseño experto de los aspectos claves de la Ingeniería de explosivos relativos a la optimización de las operaciones de excavación por voladura en mina. Se estudian los elementos de seguridad de la explotación y efectos medioambientales. Se hace uso abundante de herramientas de modelización.

5.2. Syllabus

1. Fragmentation by blasting / Fragmentación por voladura
 - 1.1. Explosive-rock interaction: I: Principles of explosive behavior / La interacción explosivo-roca. I: Principios de funcionamiento de los explosivos
 - 1.2. Explosive-rock interaction. II: Mechanisms of rock fragmentation / La interacción explosivo-roca. II: Mecanismos de fragmentación de la roca
 - 1.3. Particle size distributions / Distribuciones granulométricas
 - 1.4. Fragmentation by blasting models / Modelos de fragmentación por voladura
 - 1.5. Measurement of fragmentation by blasting / Medida de la fragmentación por voladura
2. Blast design and control. Field lab and design tools / Diseño de voladuras. Laboratorio en campo y herramientas de diseño
 - 2.1. Blast design, surface / Diseño de voladuras en banco
 - 2.2. Blast design, tunnel / Diseño de voladuras en túnel
 - 2.3. Blast design, underground production blasts / Diseño de voladuras de producción en minería subterránea
3. Monitoring, control and mitigation of the environmental impact of blasting / Métodos de medida, control y mitigación del impacto ambiental de la voladura
 - 3.1. Vibrations / Vibraciones
 - 3.2. Airblast and safety engineering / Onda aérea e ingeniería de seguridad

3.3. Detonation products. Carbon footprint and life cycle of blasting / Productos de detonación. Huella de carbono y ciclo de vida de la voladura

4. Downstream impact of blasting in the overall mine operation: Mine-to-mill optimization / La voladura en la operación minera: Optimización mina-planta

4.1. Rock damage and wall control / Daño a la roca y control del talud

4.2. Ore dilution control / Control de dilución del mineral

4.3. Mine-to-plant optimization / Optimización de la operación mina-planta

6. Schedule

6.1. Subject schedule*

Week	Type 1 activities	Type 2 activities	Distant / On-line	Assessment activities
1	<p>1.1 Duration: 02:00 Lecture</p> <p>1.2 Duration: 01:00 Lecture</p> <p>1.3 Duration: 01:00 Lecture</p>			
2	<p>1.4 Duration: 04:00 Lecture</p>			
3	<p>1.4 Duration: 01:00 Lecture</p> <p>2.1 Duration: 01:00 Lecture</p>	<p>1.5 Duration: 02:00 Laboratory assignments</p>		
4	<p>2.1 Duration: 01:00 Lecture</p> <p>2.2 Duration: 01:00 Lecture</p>	<p>2.1 Duration: 02:00 Laboratory assignments</p>		
5	<p>2.2 Duration: 01:00 Lecture</p>	<p>2.2 Duration: 02:00 Laboratory assignments</p> <p>2.3 Duration: 01:00 Laboratory assignments</p>		
6	<p>3.1 Duration: 02:00 Lecture</p> <p>3.2 Duration: 01:00 Lecture</p>	<p>3.1 Duration: 01:00 Laboratory assignments</p>		

7		2.1 (Prácticas en mina) Duration: 05:00 Additional activities		
8	3.2 Duration: 01:00 Lecture 3.3 Duration: 02:00 Lecture	3.3 Duration: 01:00 Laboratory assignments		
9	4.1 Duration: 01:00 Lecture 4.2 Duration: 01:00 Lecture 4.3 Duration: 02:00 Lecture			
10	Assessment from delivery of personal assignments and presentation of results. Duration: 03:00 Additional activities			Knowledge assessment Other assessment Progressive assessment Presential Duration: 03:00 Exam Written test Global examination Presential Duration: 03:00
11				
12				
13				
14				
15				
16				
17				

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	Knowledge assessment	Other assessment	Face-to-face	03:00	100%	5 / 10	CG2 CG1 CE15 CG5 CG3 CG4

7.1.2. Global examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
10	Exam	Written test	Face-to-face	03:00	100%	5 / 10	CG1 CE15 CG5 CG3 CG2 CG4

7.1.3. Referred (re-sit) examination

No se ha definido la evaluación extraordinaria.

7.2. Assessment criteria

Degree of acquisition of the skills specified for the course. Grado de adquisición de las competencias especificadas para la asignatura.

8. Teaching resources

8.1. Teaching resources for the subject

Name	Type	Notes
General	Bibliography	Persson, P.A., Holmberg, R., Lee, J. Rock blasting and explosives engineering. CRC Press, Boca Raton, FL, 1994.
Advanced - fragmentation	Bibliography	Sanchidrián JA. 2023. Fragmentation by blasting prediction models. En: Ingeniería de Explosivos, Cap. 15.
Advanced - slope	Bibliography	Hustrulid, W.A., McCarter, M.K., Van Zyl, D.J.A. Slope stability in surface mining. Society for Mining, Metallurgy and Exploration, Littleton, CO, 2000.
Advanced - vibrations	Bibliography	Dowding, C.H. Construction vibrations. International Society of Explosives Engineers, Cleveland, OH, 2000.
Advanced - overall	Bibliography	Proceedings, International Symposium on Rock Fragmentation by Blasting (FRAGBLAST), 2022, 2018, 2015, 2012, 2009, 2006, 2002, 1999, 1996, 1993, 1990, 1986, 1983.
Equipos análisis de voladuras (I)	Equipment	<ul style="list-style-type: none"> - 3D Laser profile
 - Borehole deviation probe
 - Seismographs
 - Velocity of detonation measurement equipment
 - Detonation pressure gauges
 - High speed video camera

Equipos de medida y análisis de voladuras (II)	Equipment	<ul style="list-style-type: none"> - Photogrammetry, land
 - UAVs.
 - Accelerometers.
 - Airblast pressure transducers.
 - Multi-channel, 10 MHz recording equipment.
 - Televiewer (optical borehole logger)
Blast design software:	Others	<ul style="list-style-type: none"> - Blastmetrix + Shapemetrix 3GSM software suite
 - JK-Simblast.
 - I-Blast 6
 - Face 3D.
 - Blastware.
 - Split.
 - Fragmenter.