TU Clausthal

Modulhandbuch

for the
Master-of-Science
“Mining Engineering”

basierend auf den Ausführungsbestimmungen vom 22.06.2021 und der
3. Änderung vom 13.06.2023

Fakultät für Energie- und Wirtschaftswissenschaften
der Technischen Universität Clausthal
20. September, 2023

Inhaltsverzeichnis

List of Abbreviations / Abkürzungsverzeichnis

B.Sc.	Bachelor of Science
E	Field trip / Exkursion
LP	Credit Points / Leistungspunkte gemäß European Credit Transfer System
h	Hours / Stunden
LN	Leistungsnachweis
LV	Course / Lehrveranstaltung
MA	Master's Thesis / Masterarbeit
MP	Module exam / Modulprüfung
MTP	Exam for one lecture of module / Modulteilprüfung
M.Sc.	Master of Science
P	Internship / Praktikum
PV	Prerequisite for exam / Prüfungsvorleistung
S	Seminar
SS	Summerterm / Sommersemester
SWS	Hours per Week / Semesterwochenstunden
T	Tutorium
ThA	Theoretical Work / Theoretische Arbeit
Ü	Excercise / Übung
V	Lecture / Vorlesung
WS	Winterterm / Wintersemester

1. Title of Module

Shaft Sinking and Advanced Mine Ventilation

2. Integrated in following Study programs

M.Sc. Mining Engineering

3. Responsible Person for the module	4. Responsible Faculty for the module	5. Number of the Module
Univ.-Prof. Dr.-Ing. Oliver Langefeld	Faculty of Energy and Economic Sciences	1

6. Language	7.CP	8. Duration	9. Offering
English	6	[ ] 1 Semester [X] 2 Semester	[ ] every semester [X] every year [ ] inconstant

10. Learning objectives / Skills

After taking the lecture and the tutorial, the student
has deep knowledge on

- Differences and characteristics of different types of shafts (haulage, ventilation, manride etc.)
- Techniques to construct pre-shafts and shafts for different purposes
- Advanced aspects of underground mine ventilation and climatization practice and environmental control

and is able to

- Plan the basic steps of a shaft sinking operation
- Identify influencing factors of a shaft sinking process
- Assess the relative risks for the whole process of each influencing factor
- Choose the best option for the technique to construct the shaft based on the location and purpose it
- Calculate time needed for different shaft sinking techniques based on the shaft dimensions
- Analyze and solve engineering problems occurring during operation

Courses

11. No.	12. Course title	13. Lecturer	14. Course No.	15. Course type	16. SWS	17. Workload Contact hours- / Self-Study time
1	Shaft Sinking	Univ.-Prof. Dr.-Ing. Oliver Langefeld	W 6984	V	1	28 h / 62 h
2	Tutorial for Shaft Sinking		W 6985	Ü	1	
3	Advanced Mine Ventilation and Climatization		S 6986	V	2	28 h / 62 h
				Sum:	4	56 h / 124 h

On No. 1-3: Shaft Sinking and Advanced Mine Ventilation Module

18. Suggested requirements	Basics of underground mining

19. Objectives	Shaft Sinking: Specific learning objectives for the single course elements are delivered during the course. The overall course objectives are: ♦ Explaining different types of shafts and their characteristic properties ♦ Choosing shaft sinking methods, explain the influencing factors and design the shaft sinking process ♦ Deciding on the machinery and technologies needed based on shaft dimensions and geological factors ♦ Planning of shaft sinking operations under a variety of conditions Advanced Mine Ventilation: This course develops the knowledge and skills in advanced aspects of underground mine ventilation and climatization practice and environmental control. In addition to the course Mine Ventilation and Climatization on an advanced level, emphasis is also placed on operational aspects such as controlling complex mine ventilation networks and planning ventilation and climatization requirements to manage both safety and production related risks. At the end of the course, the student will be able to: ♦ Demonstrate practical skill necessary to undertake an underground ventilation and climatization survey together with necessary documentation, analysis and interpretation of results; ♦ Demonstrate the application of advanced network analysis to ventilation and climatization systems, including thermodynamic aspects; ♦ Identify the requirements and issues associated with the application of appropriate ventilation and climatization monitoring and measurement systems; ♦ Develop ventilation designs with regards to environmental hazards found in mines and to apply the ventilation control measures that detect, monitor, minimize and/or manage these hazards ♦ Identify, analyze and solve engineering problems regarding gas and dust occurrences ♦ Identify, analyze and solve engineering problems resulting from the need to conduct underground mine ventilation and climatization and to enable the students to apply this knowledge in order to develop, discuss and justify proper engineering solutions to those tasks and problems. ♦ Identify, analyze and solve engineering problems related to mining ventilation applications by using appropriate simulation software tool
20. Media	Shaft Sinking: Oral presentation and discussion (supported by analog and digital media), Personal Talk, Videos, Papers and Books Advanced Mine Ventilation: Learning Videos, Online Forum, Lecture (Activity-based / Just-in-time teaching and learning approach), Beamer-Presentation, Tutorials, Application of simulation software

21. Literature	<u>Shaft Sinking:</u> ♦ SME Mining Engineering Handbook ♦ Surface and Underground Excavations ♦ Case Study Information Material ♦ Secondary literature-to be announced in the lecture <u>Advanced Mine Ventilation:</u> ♦ McPherson, M. (1993): Subsurface Ventilation and Environmental Engineering. ♦ Hartman, Howard L., et al. Mine ventilation and air conditioning. John Wiley & Sons, 2012. ♦ Additional secondary literature-to be announced in the lecture.
22. Other	<u>Shaft Sinking:</u> ♦ Course Outline: • Characterization and Classification of vertical openings • Technical and organizational Planning of Shaft Sinking Projects • Dimensioning and construction of Pre-Shafts • Shaft Sinking with conventional drilling and blasting • Consolidation methods (Freezing shaft and injection method) • Shaft Boring Methods • Shaft Reinforcement, Support and Lining • Shaft Haulage Technology (Basics) ♦ The Tutorial is held in a block course within three days. The date will be announced at the beginning of the semester. <u>Advanced Mine Ventilation:</u> ♦ Course Outline: • Review of mine ventilation Basics • Ventilation Network Analysis and surveys • Planning and optimization of mine ventilation systems • Dust and Gas emissions control in mines • Design and Planning of Mine refrigeration systems • Mine Ventilation Project • Application of the ventilation software VentsimTM ♦ Assessment will only be offered in the summer term.

Assessment					
23. No.	24. Respective Lecture	25. Type	26. CP	27. Grading	28. Emphasis
1	Shaft Sinking	LV	3	graded	50 %
2	Tutorial for Shaft Sinking	PV			
3	Advanced Mine Ventilation and Climatization	LV	3	graded	50 %

On No. 1 and 2: Lecture and Tutorial Shaft Sinking	
29a. Type of Assessment	Oral examination (30 – 40 min) or Written examination (90 min), will be announced at start of the semester
30a. Examiner	Univ.-Prof. Dr.-Ing. Oliver Langefeld
31a. Compulsory Prerequisite for Exam	Tutorial Shaft Sinking and Deep Foundations

On No. 3: Advanced Mine Ventilation and Climatization	
29b. Type of Assessment	20 minute presentation in plenary followed by discussion (together about 30 minutes)
30b. Examiner	Univ.-Prof. Dr.-Ing. Oliver Langefeld
31b. Compulsory Prerequisite for Exam	-

1. Title of Module

International Mining

2. Integrated in following Study programs			
M.Sc. Mining Engineering			
3. Responsible Person for the module Univ.-Prof. Dr.-Ing. habil. Tudeshki		4. Responsible Faculty for the module Faculty of Energy and Economic Sciences	5. Number of the Module 2
6. Language English	7. LP 6	8. Duration [X] 1 Semester [ ] 2 Semester	9. Offering [ ] every semester [X] every year [ ] inconstant

10. Learning objectives / Skills

After taking the lecture and the tutorial, the student has deep knowledge on

- global mining industry and markets, price setting processes
- project feasibility evaluation and project financing alternatives

and is able to

- evaluate a mining project
- create a feasibility study
- work out a financing plan

Courses

11. No.	12. Course title	13. Lecturer	14. Course No.	15. Course type	16. SWS	17. Workload Contact hours- / Self-Study time
1	International Mining	Univ.-Prof. Dr.-Ing. habil. Tudeshki	W 6029	V	2	24 h / 36 h
2	Seminar for International Mining			S		6 h / 24 h
3	Mining and Finance		W 6017	V	2	24 h / 36 h
4	Tutorial Mining and Finance			Ü		6 h / 24 h
				Sum:	4	60 h / 120 h

On No. 1+2: Lecture and Seminar for International Mining

18a. Suggested requirements	-

19a. Objectives	The students receive factual knowledge about the global mining industry, the worldwide mining and the associated commodity markets as well as insight into the processes of pricing. In addition to basic mining technologies they will acquire knowledge of special mining technologies. In the seminar the students will work on a special topic of international mining and train the capabilities of free speech.
20a. Media	Lecture, projector-presentation, lecture notes PC-based spreadsheet analysis
21a. Literature	announcement in the lecture
22a. Other	♦ Course Outline: • International commodity markets: o Reserves, consumption/production o Countries, companies, market conditions o Stock exchanges for commodities, prices • Mining technologies of selected international mining projects o Surface and underground mining o Special technologies, e.g. marine mining • Independent seminar on a special topic of international mining
On No. 3+4: Lecture and Tutorial Mining and Finance	
18b. Suggested requirements	-
19b. Objectives	Students will acquire knowledge of the necessary steps for preparation of feasibility studies, project development and project financing. Mediation of skills to assess international raw material projects economically is an important goal of the lecture. In the tutorial the students work in small groups on practical examples, prepare a report and present the results in a seminar.
20b. Media	♦ Lecture, projector-presentation, lecture notes ♦ PC-based spreadsheet analysis
21b. Literature	Announcement in the lecture
22b. Other	♦ Course Outline: • Mining project participants • Type and content of project studies • Risk assessment • Type of project financing • Market analysis and prices, project costs ♦ Group work of students on a feasibility study with final presentation of results

Assessment					
23. No.	24. Respective Lecture	25. Type	26. LP	27. Grading	28. Emphasis
1	Lecture International Mining	MTP	3	graded	50 %
2	Seminar for International Mining				
3	Mining and Finance	MTP	3	graded	50 %
4	Tutorial for Mining and Finance				

On No. 1&2: Lecture International Mining	
29a. Type of Assessment	Oral examination (30-40 min)
30a. Examiner	Univ.-Prof. Dr.-Ing. habil. Tudeshki
31a. Compulsory Prerequisite for Exam	Seminar for International Mining

On No. 2: Seminar for International Mining	
29b. Type of Assessment	Seminar presentation
30b. Examiner	Univ.-Prof. Dr.-Ing. habil. Tudeshki
31b. Compulsory Prerequisite for Exam	-

On No. 3: Lecture Mining and Finance	
29c. Type of Assessment	Oral or written Examination (max. 45 minutes)
30c. Examiner	Univ.-Prof. Dr.-Ing. habil. Tudeshki
31c. Compulsory Prerequisite for Exam	Tutorial for Mining and Finance

On No. 4: Tutorial for Mining and Finance	
29d. Type of Assessment	Group work of students with final presentation of results
30d. Examiner	Univ.-Prof. Dr.-Ing. habil. Tudeshki
31d. Compulsory Prerequisite for Exam	-

1. Title of Module

Geomatics

2. Integrated in following Study programs

Master Mining Engineering, Master Computer Science

3. Responsible Person for the module		4. Responsible Faculty for the module	5. Number of the Module
Prof. Dr.-Ing. Paffenholz		Faculty of Energy and Economic Sciences	
6. Language	7. LP	8. Duration	9. Offering
English	6	[ ] 1 Semester [X] 2 Semesters	[ ] every semester [X] every year [ ] inconstant

10. Learning objectives / Skills

This module aims at introducing basic knowledge in the scope of geographic information systems (GIS) as well as remote sensing.

After successful completion of this module, the students are familiar with:

- The basic principles of GIS and their functionalities; including an overview of web-based GIS;
- The different geospatial data types with respect to their pros and cons;
- The fundamentals of spatio-temporal analysis and modeling approaches for geodata
- The basics of remote sensing and the corresponding image data;
- The fundamentals of digital image processing techniques.

and is able to

- Use GIS software, like QGIS, to apply basic methods for spatial analysis and modeling of surfaces on various data, e.g., captured by terrestrial sensors, like laser scanner, and remote sensing sensors, like optical sensors on satellites;
- Judge about digital images and apply fundamental image processing techniques with respect to selected applications in the context of mining engineering.

Courses

11. No.	12. Course title	13. Lecturer	14. Course No.	15. Course type	16. SWS	17. Workload Contact hours- / Self-Study time
1	GIS-based spatio-temporal analysis and modeling	Prof. Paffenholz	S 6309	2V + 1Ü	3	42 h / 48 h

2	Remote sensing	Prof. Paffenholz	W 6354	1V + 1Ü	2	28 h / 62 h
				Sum:	5	70 h / 110 h

On No. 1: GIS-based spatio-temporal analysis and modeling	
18. Suggested requirements	- None
19. Objectives	This lecture introduces following selected topics to learn about the fundamentals of GIS: - Basic principles of GIS and their functionalities introduced alongside with the open source software QGIS; - Map projections and coordinate reference systems in GIS; - Geospatial data types: vector and raster; - Topology; - Overview of selected basic spatio-temporal analysis and modeling approaches like interpolation methods to create surfaces in a) vector representation, e.g., Delaunay Triangulation and b) raster representation, e.g., inverse distance weighting. - Web-based GIS and its applications at a glance. The lab work deals with exemplary free available data sets, which have to be analyzed with the open source software QGIS and an associated Moodle course. The results of the lab work have to be documented and to be discussed.
20. Media	- Projector presentation, Stud.IP, Moodle, Smartboard, open source software QGIS
21. Literature	- Bernhardsen, Tor (2002): Geographic information systems. An introduction. 3rd ed. New York: Wiley. Online verfügbar unter http://proquest.tech.safaribooksonline.de/9780471419686. - Bolstad, Paul (2016): GIS fundamentals. A first text on geographic information systems. 6th edition. Acton, MA, White Bear Lake, Minnesota: XanEdu. Online available under www.paulbolstad.net/gisbook.html. The above-mentioned literature gives an overview. In the lecture, more in-depth literature is given for selected topics.
22. Other	./.

On No. 2: Remote Sensing	
18. Suggested requirements	- None

19. Objectives	This lecture introduces following selected topics in the scope of remote sensing: - Fundamentals of the physics of remote sensing; - Overview of sensors and platforms stemming from ground based, airborne and spaceborne domain; - Fundamentals of digital image processing techniques divided in low-level (image preprocessing), mid-level (e.g. image segmentation) and high-level (e.g. object model) processing; The lab work deals with applications of digital image processing techniques for selected free available data sets, which have to be analyzed with the open source software Orfeo toolbox and an associated Moodle course. The results of the lab work have to be documented and to be discussed.
20. Media	- Projector presentation, Stud.IP, Moodle, Smartboard, open source software Orfeo toolbox
21. Literature	- Rees, W.G.: Physical Principles of Remote Sensing. 3. Aufl., Cambridge University Press, 2012. - Luhmann, T.; Robson, Stuart; Kyle, Stephen; Boehm, Jan (2014): Close-range photogrammetry and 3D imaging. 2nd edition. Berlin: de Gruyter (De Gruyter textbook). The above-mentioned literature gives an overview. In the lecture, more in-depth literature is given for selected topics.
22. Other	./.

Assessment

23. No.	24. Respective Lecture	25. Type	26. LP	27. Grading	28. Emphasis
1	GIS-based spatio-temporal analysis and modeling	MTP	3	graded	50 %
2	Remote sensing	MTP	3	graded	50 %

On No. 1: GIS-based spatio-temporal analysis and modeling

29. Type of Assessment	Written exam (60 minutes) or oral exam (20 minutes, individual exam)
30. Examiner	Prof. Paffenholz
31. Compulsory Prerequisite for Exam	./.

On No. 2: Remote sensing

29. Type of Assessment	Written exam (60 minutes) or oral exam (20 minutes, individual exam)
30. Examiner	Prof. Dr. J.-A. Paffenholz
31. Compulsory Prerequisite for Exam	./.

1. Title of Module

Mineral Resources

2. Integrated in following Study programs			
M.Sc. Mining Engineering			
3. Responsible Person for the module Prof. Dr. Bernd Lehmann		4. Responsible Faculty for the module Faculty of Energy and Economic Sciences	5. Number of the Module 4
6. Language English	7. LP 6	8. Duration [X] 1 Semester [ ] 2 Semester	9. Offering [ ] every semester [X] every year [ ] inconstant
10. Learning objectives / Skills After taking the lecture and the tutorial, the student has knowledge on ♦ see objectives of the two lectures below and is able to ♦ understand some major geological and mineralogical features of ore deposit types for copper, gold and iron ♦ apply geostatistical methods to ore deposits			

Courses

11. No.	12. Course title	13. Lecturer	14. Course No.	15. Course type	16. SWS	17. Workload Contact hours- / Self-Study time
1	Geostatistics	Dr. Rainer Müller	W 4637	V	2	28 h / 62 h
2	Economic Geology	Prof. Dr. Bernd Lehmann	W 6220	V	2	28 h / 62 h
				Sum:	4	56 h / 124 h

On No. 1: Advanced Geostatistics

18a. Suggested requirements	-
19a. Objectives	The students will learn to understand the principles and calculation methods of geostatistical models and their applications (e.g. kriging) in modern simulation methods.
20a. Media	Lecture, projector-presentation, lecture notes

21a. Literature	♦ Davis J (2002) Statistics and data analysis in geology. 3rd ed, Wiley, 638 p. ♦ Clark I, Harper WV (2000) Practical geostatistics 2000. Ecosse, CD/442 ♦ Olea RA (1999) Geostatistics for engineers and Earth scientists. Kluwer, 303 p.
22a. Other	♦ Course Outline: • Short repetition of basic statistics • Fundamentals of geostatistics, Variography • Calculation, evaluation and interpretation of variograms • Use of geostatistical basic data in interpolation methods • Kriging (2D and 3D)
On No. 2: Economic Geology	
18b. Suggested requirements	-
19b. Objectives	Basic knowledge of geology related to mineral deposits and understanding ore deposits in the framework of Earth evolution.
20b. Media	Lecture, projector-presentation, lecture notes
21b. Literature	♦ Pohl WL (2013) Economic geology: principles and practice. Wiley-Blackwell, 680 p.
22b. Other	♦ Course Outline: Structure of the Earth, geologic time, global geological cycles, rocks and ore, water, magmatic and hydrothermal ore deposits, weathering ♦ Recommended: 1-day field trip (Geology of the Harz Mountains)

Assessment

23. No.	24. Respective Lecture	25. Type	26. LP	27. Grading	28. Emphasis
1	Advanced Geostatistics	MTP	3	graded	50 %
2	Economic Geology	MTP	3	graded	50 %

On No. 1: Advanced Geostatistics	
29a. Type of Assessment	Oral (30 min) or written examination (60 min)
30a. Examiner	Dr. Rainer Müller
31a. Compulsory Prerequisite for Exam	-
On No. 2: Economic Geology	
29b. Type of Assessment	Oral (30 min) or written examination (60 min)
30b. Examiner	Prof. Dr. Bernd Lehmann
31b. Compulsory Prerequisite for Exam	-

1. Title of Module			
IoT and Digitalization for Circular Economy			
2. Integrated in following Study programs Master Mining Engineering			
3. Responsible Person for the module Prof. Dr. B. Leiding		4. Responsible Faculty for the module Faculty of Mathematics/ Computer Science and Mechanical Engineering	5. Number of the Module 5
6. Language English	7. LP 6	8. Duration [X] 1 Semester [ ] 2 Semester	9. Offering [ ] every semester [X] every year [ ] inconstant
10. Learning objectives / Skills After successfully finishing the lecture, the students have knowledge of the field of system design and control engineering using the example of the Internet of Things and open cyberphysical systems in the field of raw material extraction and processing (mining engineering), as well as raw material assurance and resource efficiency. Furthermore, they are able to ▪ understand interrelations, in particular predicting the behaviour of systems ▪ apply the knowledge to new problems and ▪ partially evaluate the results in terms of correctness and quality.			

Courses						
11. No.	12. Course title	13. Lecturer	14. Course No.	15. Course type	16. SWS	17. Workload Contact hours- / Self-Study time
1	IoT and Digitalization for Circular Economy	Prof. Dr. B. Leiding	S 1637	2V + 2L	4	56h / 124h
				Sum:	4	56h / 124h
On No. 1:						
18a. Suggested requirements	Basic programming skills					

19a. Objectives	▪ Introduction to IoT and cyberphysical systems in the circular economy ▪ Sensors and actuators for IoT, control and process systems of the circular economy ▪ Understanding (sensor) signals ▪ Control engineering for mechatronic systems ▪ Modelling of cyberphysical systems and processes of the circular economy ▪ Experiments on IoT ▪ Data science (applied) on circular economy topics ▪ Development of intelligent control and planning processes to increase sustainability The lecture is characterised by a practical part, i.e. programming and modelling tasks are to be solved regularly and demonstrated in small exercise groups. In addition, a practical project in the field of circular economy will be carried out, which combines the basics of the course with exciting topics from the field of application.
20a. Media	Presentation, PC-Pool
21a. Literature	Will be announced during the lecture
22a. Other	

Assessment

23. No.	24. Respective Lecture	25. Type	26. LP	27. Grading	28. Emphasis
1	IoT and Digitalization for Circular Economy	MP	6	graded	100 %

29a. Type of Assessment	K (45 Min) oder M
30a. Examiner	Prof. Dr. B. Leiding
31a. Compulsory Prerequisite for Exam	-

1. Title of Module

Underground Mining Equipment

2. Integrated in following Study programs			
M.Sc. Mining Engineering			
3. Responsible Person for the module Univ.-Prof. Dr.-Ing. Oliver Langefeld		4. Responsible Faculty for the module Faculty of Energy and Economic Sciences	5. Number of the Module 6
6. Language English	7. LP 6	8. Duration [X] 1 Semester [ ] 2 Semester	9. Offering [ ] every semester [X] every year [ ] inconstant

10. Learning objectives / Skills

After the lecture and the project, the student is able to

- Explain the layout and operating mode of underground mining machinery in soft and hard rock
- Design the size of selected machines by using formulas and experienced data with MS Excel
- Decide which kind and size of machinery to choose for a specific situation

By the successful realization of the project, the student shows his/her ability to

- describe a machine and its task
- identify connect machine and describe their interface
- identify and describe the operating conditions
- illustrate the design considerations and calculations
- evaluate and describe the machine safety, ergonomics and ethnics
- link the lecture topics to a given machine
- perform a research on the named topics

Courses

11. No.	12. Course title	13. Lecturer	14. Course No.	15. Course type	16. SWS	17. Workload Contact hours- / Self-Study time
1	Underground Mining Equipment	Univ.-Prof. Dr.-Ing. Oliver Langefeld	W 6989	V	3	32 h / 88 h
2	Project on Underground Mining Equipment	Univ.-Prof. Dr.-Ing. Oliver Langefeld	W 6991	T	1	4 h / 54 h
				Sum:	4	56 h / 124 h

On No. 1: Underground Mining Equipment	
18a. Suggested requirements	Basics of underground mining, basic skills in MS Excel, Basics in mechanical engineering
19a. Objectives	Specific learning objectives for the single course elements are delivered during the course. The overall course objectives are: ♦ Explaining the layout and operating mode of underground mining machinery in both soft rock and hard rock. ♦ Designing the size of the machines by using formulas and experienced data with MS Excel ♦ Deciding which kind and size of machinery is the right for a special application.
20a. Media	Oral presentation and discussion (supported by analog and digital media), Personal Talk, Videos, Papers and Books
21a. Literature	Bise, Christopher J. (2003): Mining engineering analysis. 2nd ed. Littleton, Colo: Society for Mining Metallurgy and Exploration. Darling, Peter (Ed.) (2011): SME mining engineering handbook. 3. ed. Englewood, Col.: SME - Soc. for Mining Metallurgy and Exploration. Junker, Martin (Ed.) (2009): Strata control in in-seam roadways. Essen: VGE Verlag. Junker, Martin; Lemke, Michael; Heiderich, Rolf-Michael; Langefeld, Oliver; Mozar, Armin; Paschedag, Ulrich et al. (2018): Technical developments in coal winning. Essen: Vulkan-Verlag GmbH (Documentation of technical developments at RAG, volume 2). Peng, Syd S. (2006): Longwall mining. 2. ed. Morgantown, WVa.: West Virginia Univ. Department of Mining Engineering. Tomlingson, Paul D. (2010): Equipment management. Key to equipment reliability and productivity in mining. 2nd ed. Littleton, Colo., USA: Society for Minig Metallurgy and Exploration.
22a. Other	♦ Course Outline: • The mines and the tasks of its equipment • Safety first: Risk Assessment for Mining Machinery • The detail is important: Equipment Selection • Basics of Design • Zoom to extraction: Production in longwalls • Zoom to hydraulics: Support in longwalls • Infrastructure: The backbone of a mine • Road development: Road headers and drilling machines for small diameters • Keep it working: Maintenance ♦ In case the needed resources are available, a supporting fieldstrip is offered connected directly to one of the lecture topics. If offered, students can obtain bonus points based on §15 Abs. 5 APO for an active participation proofed by an assignment on a given task.

On No. 2: Project on Underground Mining Equipment	
18b. Suggested requirements	See above
19b. Objectives	By the successful realization of the project, the student shows his/her ability to ♦ describe a machine and its task ♦ identify connect machine and describe their interface ♦ identify and describe the operating conditions ♦ illustrate the design considerations and calculations ♦ evaluate and describe the machine safety, ergonomics and ethnics ♦ link the lecture topics to a given machine ♦ perform a research on the named topics
20b. Media	Requirements and task documentation in a compendium, Sources of information literature, web and personal interviews
21a. Literature	See above
22a. Other	♦ Besides the lectures, each student works on an individual project to apply and deepen the knowledge on mining machinery and equipment. Therefore, each students gets a machine or equipment to investigate. The results of the investigation are summarized in a scientific report.

Assessment					
23. No.	24. Respective Lecture	25. Type	26. LP	27. Grading	28. Emphasis
1	Underground Mining Equipment	K	4	graded	75 %
2	Project on Underground Mining Equipment	PA	2	graded	25 %

On No. 1: Underground Mining Equipment	
29a. Type of Assessment	Written (120 min) examination
30a. Examiner	Univ.-Prof. Dr.-Ing. Oliver Langefeld
31a. Compulsory Prerequisite for Exam	-

On No. 2: Project on Underground Mining Equipment	
29b. Type of Assessment	Assignment (project work)
30b. Examiner	Univ.-Prof. Dr.-Ing. Oliver Langefeld
31b. Compulsory Prerequisite for Exam	-

1. Title of Module

Advanced Rock Mechanics

2. Integrated in following Study programs			
M.Sc. Mining Engineering			
3. Responsible Person for the module Dr.-Ing. R. Wolters-Zhao		4. Responsible Faculty for the module Faculty of Energy and Economic Sciences	5. Number of the Module 7
6. Language English	7. LP 6	8. Duration [X] 1 Semester [ ] 2 Semester	9. Offering [ ] every semester [X] every year [ ] inconstant

10. Learning objectives / Skills

After taking the lecture and the tutorial, the student

has deep knowledge on

- Physical dimensions SI-System / US-System
- Mechanical, thermal, hydraulically material properties of rocks and rock masses
- Basics of genesis of earth / site investigation techniques
- Laboratory tests - testing equipment, testing techniques, test evaluation, determination of physical parameters
- Analytical procedures to calculate stresses and strains in the vicinity of underground structures
- Evaluation of numerical calculated load bearing behaviour of underground structures
- Safety assessment of static stability, tightness, integrity, surface subsidence

and is able to

- handle the basics of geotechnical safety assessments for underground excavations
- determine geotechnical parameters for rock mass as well as parameters belonging to constitutive models based on lab tests
- compute the state of stress and strain in the rock mass surrounding underground excavations by using analytical solutions
- read, verify, validate numerically computed results to evaluate static stability and tightness of underground structures

Courses						
11. No.	12. Course title	13. Lecturer	14. Course No.	15. Course type	16. SWS	17. Workload Contact hours- / Self-Study time
1	Advanced Rock Mechanics	Dr.-Ing. R. Wolters-Zhao	S 6250	V	2	28 h / 62 h
2	Tutorial for Advanced Rock Mechanics		S 6251	Ü	2	28 h / 62 h
				Sum:	4	56 h / 124 h

On No. 1+2: Advanced Rock Mechanics Module	
18. Suggested requirements	-
19. Objectives	Geological and engineering classification of rock and rock mass Basics of geology, earth history, structure of earth, site investigation techniques Laboratory testing - testing techniques, test evaluation, derivation of physical parameters Rock mechanical calculations based on analytical solutions Analysis and Evaluation of numerical computations Safety assessment
20. Media	Lecture, projector presentation, lecture notes, exercises, experimental equipment
21. Literature	/1/ Jonson, R.B; DeGraff, J.V. (1988): Principles of Engineering Geology, Wiley. /2/ Kehew, A. E. (1995): Geology for Engineers & Environmental Scientists, Prentice Hall, 2nd. Ed. /3/ Biniawski, Z.T. (1984): Rock mechanics design in mining and tunneling, A.A. Balkema, Rotterdam, Boston. /4/ Brady, B.H.G.; Brown, E.T. (1985): Rock mechanics for underground mining, London, Georg, Allen & Unwin. /5/ Barton, N., Lien, R., Lunde, J.(1974): Engineering Classification of Rock Masses for the Design of Tunnel Support, Rock Mechanics 6, S. 189-236. /6/ Dobrin, M.B. (1976): Introduction to Geophysical Prospecting. Third edition, McGraw-Hill Book Company. /7/ Woods, R.D. (1994): Geophysical Characterization of Sites. Volume prepared by the International Society for Soil Mechanics and Foundation Engineering, (ISSMFE), Technical Committee No. 10 for the XIII. International Conference of Soil Mechanics and Foundation Engineering, (ICSMFE), New Dehli, India.

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22. Other	♦ Course Outline: • Overview area of expertise • Geological basics (structure and genesis of rock mass, earth history) • Exploration techniques • Lab testing (testing technique, analysis, parameter determination) • Field testing • Primary stress • Rock mechanical calculations (analytical calculations, verification, validation, interpretation of numerical calculated results) • Safety assessment (comparison between computed stresses and strength)

Assessment

23. No.	24. Respective Lecture	25. Type	26. LP	27. Grading	28. Emphasis
1	Advanced Rock Mechanics	MP	6	graded	100 %
2	Tutorial for Advanced Rock Mechanics				

On No. 1+2: Advanced Rock Mechanics Module

29. Type of Assessment	Written Examination (120 min)
30. Examiner	Dr.-Ing. R. Wolters-Zhao
31. Compulsory Prerequisite for Exam	-

1. Title of Module

Mining and Environment

2. Integrated in following Study programs			
M.Sc. Mining Engineering			
3. Responsible Person for the module Univ.-Prof. Dr.-Ing. habil. Tudeshki		4. Responsible Faculty for the module Faculty of Energy and Economic Sciences	5. Number of the Module 8
6. Language English	7. LP 6	8. Duration [X] 1 Semester [ ] 2 Semester	9. Offering [ ] every semester [X] every year [ ] inconstant

10. Learning objectives / Skills

After taking the lecture and the tutorial, the student has deep knowledge on

- different effects of mining activities on the environment, e.g. dust, noise and vibrations, dewatering
- sources of emissions and immissions
- surface and groundwater types, behavior and management
- slope stability assessment
- mine closure and mine site reclamation

and is able to

- evaluate the environmental impact of mining activities
- develop prevention and compensation strategies
- work out a mine closure concept and reclamation plan

Courses

11. No.	12. Course title	13. Lecturer	14. Course No.	15. Course type	16. SWS	17. Workload Contact hours- / Self-Study time
1	Mining and Environment	Univ.-Prof. Dr.-Ing. habil. Tudeshki	W 6068	V	2	28 h / 32 h
2	Tutorial for Mining and Environment		W 6078	Ü	2	14 h / 46 h
				Sum:	4	42 h / 78 h

On No. 1+2: Lecture and Tutorial for Mining and Environment

18a. Suggested requirements	-

19a. Objectives	Students will get to know different types of emissions and impacts generated by mining activities, which have effect on the environment. Main focus is set on dust, noise and vibrations, dewatering, slope stability and mine site reclamation. Based on the evaluation of the environmental impact of mining activities, students will understand prevention and compensation strategies as well as mine closure concepts and reclamation plans. During the tutorial students will work on practical exercises of different environmental issues, present their results and discuss them with all participants of the tutorial.
20a. Media	Lecture, projector-presentation, lecture notes.
21a. Literature	Announcement in the lecture
22a. Other	• Lecture content: o Dust, noise and vibrations o Soil physics, soil and rock mechanics o Hydrogeology and hydrology o Water management of open pits o Acid mine drainage o Dewatering technologies o Dimensioning of water wells o Slope stability o Legal aspects of reclamation o Reclamation goals and technologies • Tutorial o Practical examples o Exercises o Presentation and discussion

Assessment					
23. No.	24. Respective Lecture	25. Type	26. LP	27. Grading	28. Emphasis
1	Mining and Environment	MP	6	graded	100 %
2	Tutorial for Mining and Environment				
On No. 1+2: Mining and Environment Module					
29. Type of Assessment	Oral (30 min) or written (max. 90 min) Examination				
30. Examiner	Univ.-Prof. Dr.-Ing. habil. Tudeshki				
31. Compulsory Prerequisite for Exam	-				

1. Title of Module

Mineral Processing

2. Integrated in following Study programs			
M.Sc. Mining Engineering			
3. Responsible Person for the module Dr.- Ing. Annett Wollmann		4. Responsible Faculty for the module Faculty of Mathematics/Computer Science and Mechanical Engineering	5. Number of the Module 9
6. Language English	7. LP 4	8. Duration [X] 1 Semester [ ] 2 Semester	9. Offering [ ] every semester [X] every year [ ] inconstant

10. Learning objectives / Skills

After taking the lecture and the tutorial, the student

has deep knowledge on

- different types of minerals,
- different machineries used
- different processes for mineral extraction

and is able to

- Develop a process chain for mineral processing
- Calculate critical parameters for processes
- Evaluate techno-economic feasibility

Courses

11. No.	12. Course title	13. Lecturer	14. Course No.	15. Course type	16. SWS	17. Workload Contact hours- / Self-Study time
1	Mineral Processing	Dr.-Ing. Annett Wollmann	W 8611	V	3	42 h / 48 h
2	Tutorial for Mineral Processing			Ü		
				Sum:	3	42 h / 48 h

On No. 1+2: Mineral Processing Module

18. Suggested requirements	-

19. Objectives	This lecture is intended to outline the basic principles of mineral processing arranged in unit operations. In order to deepen the understanding of the challenges occurring in particular applications and to facilitate the orientation of the students within the field, importance will be attached to the equipment employed in mineral processing. Finally, to appreciate the interdependence of the various unit operations a few worked examples.
20. Media	Lecture, projector-based presentation, script, exercises and group work
21. Literature	♦ Mineral Processing Technology (Eds. B.A. Will, T.J. Napier-Munn, ISBN-10: 0-7506-4450-8, 7th edition, Elsevier, 2006) ♦ Principles of Mineral Processing (Eds. M.C. Fuerstenau, K.N. Nan, ISBN 0-87335-176-3, SME, 2003)
22. Other	♦ Course Outline: • Introduction • Fundamentals • Size reduction • Sizing separation • Concentration separation • Materials handling

Assessment					
23. No.	24. Respective Lecture	25. Type	26. LP	27. Grading	28. Emphasis
1	Mineral Processing	MP	4	graded	100 %
2	Tutorial for Mineral Processing				
On No. 1+2: Mineral Processing Module					
29. Type of Assessment	Written Examination (120 min)				
30. Examiner	Dr.-Ing. Annett Wollmann				
31. Compulsory Prerequisite for Exam	-				

1. Title of Module

Responsible Mining

2. Integrated in following Study programs			
M.Sc. Mining Engineering			
3. Responsible Person for the module Univ.-Prof. Dr.-Ing. Oliver Langefeld		4. Responsible Faculty for the module Department of Underground Mining Methods and Machinery	5. Number of the Module 10
6. Language English	7. CP 6	8. Duration [X] 1 Semester [ ] 2 Semester	9. Offering [ ] every semester [X] every year [ ] inconstant

10. Learning objectives / Skills

This course develops the knowledge and skills in aspects of responsible mine planning with special consideration of safety in underground mining.

At the end of the course, the student will be able to:

- Identify, analyze and solve engineering problems resulting from the need to conduct mine planning and to apply this knowledge in order to develop, discuss and justify proper engineering solutions to those tasks and problems.
- Demonstrate practical skill necessary to undertake an underground mine planning survey together with necessary documentation, analysis and interpretation of results;
  - Understand market needs and raw material politics
  - Compile technical, economic and other data required for mine planning;
  - Understand reserve estimation methods
  - Select a suitable mining method and related equipment for a given deposit;
  - Plan and schedule mine development and production; run a draft pre-feasibility study (project work).
  - Identify the major risks in underground mining and design suitable technical, organizational and personal measures to management the risks effetely

Courses

11. No.	12. Course title	13. Lecturer	14. Course No.	15. Course type	16. SWS	17. Workload Contact hours- / Self-Study time
1	Responsible Mine Planning	Univ.-Prof. Dr.-Ing. Oliver Langefeld	S 6993	V	2	28 h / 62 h

2	Tutorial for Responsible Mine Planning	Univ.-Prof. Dr.-Ing. Oliver Langefeld	S 6994	Ü	1	14 h / 16 h
3	Underground Mine Safety	Sandra Nowosad, M.sc.	S 6992	V	1	14 h / 46 h
				Sum:	4	56 h / 124 h

On No. 1+2: Responsible Mine Planning	
18. Suggested requirements	Mining Basics, Economical Basics
19. Objectives	This course develops the knowledge and skills in aspects of underground mine planning and environmental control. At the end of the course, the student will be able to: ♦ Identify, analyze and solve engineering problems resulting from the need to conduct mine planning and to enable the students to apply this knowledge in order to develop, discuss and justify proper engineering solutions to those tasks and problems. ♦ Demonstrate practical skill necessary to undertake an underground mine planning survey together with necessary documentation, analysis and interpretation of results; • Understand market needs and raw material politics (example to potash and salt) • Compile technical, economic and other data required for mine planning; • Understand reserve estimation methods • Select a suitable mining method and related equipment for a given deposit; • Plan and schedule mine development and production; run a draft pre-feasibility study (project work).
20. Media	Lecture (Activity-based Learning Approach), Beamer-Presentation, Script, Tutorials, Group and Project works
21. Literature	♦ Hustrulid, W. (1982): Undeground Mining Methods Handbook ♦ Haldar, S. (2013): Mineral exploration: principles and application ♦ Dimitrakopoulos, R. (2013): Ore Reserve Estimation and Strategic Mine Planning: Stochastic Models and Optimizations with Case Studies ♦ Yang, B. (2012): Regulatory Governance and Risk Management: Occupational Health and Safety in the Coal Mining Industry ♦ Rudenno, V. (2012): The mining valuation handbook: mining and energy valuation for investors and management ♦ Secondary literature-to be announced in the lecture

22. Other	♦ Course Outline: • Objectives, Classification and general aspects Underground Mine Planning • Stages of Mine Planning; Principles of Project Management • Exploration and Classification of reserves • Mine life / capacities • Mining methods selection • Equipment / Fleet selection • Regulatory environment; Site closure / environmental design • Capital and operating cost estimation ♦ The Tutorial is held in a block course within two days. The date is announced at the beginning of the corresponding semester
On No. 2: Underground Mine Safety	
18b. Suggested requirements	Internship / work experience in underground mining
19b. Objectives	Develop an understanding for necessities and methods of underground mine safety. Enable a production engineer to identify and assess underground hazards and propose/ implement suitable safety measures.
20b. Media	Lecture (Activity-based Learning Approach), Projector-supported presentation, Script, Group works.
21b. Literature	• Junghans, R.: Lehrbuch der Sicherheitstechnik. Band 1: Grubensicherheit (Textbook of Underground Mine Safety, in German). VEB Deutscher Verlag für Grundstoffindustrie, Leipzig, 1969. • Council Directive 89/391/EEC of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work. • Council Directive 92/104/EEC of 3 December 1992 on the minimum requirements for improving the safety and health protection of workers in surface and underground mineral-extracting industries (twelfth individual Directive within the meaning of Article 16 (1) of Directive 89/391/EEC). • Directive 2006/42/EC OF the European Parliament and of the Council of 17 May 2006 on machinery and amending Directive 95/16/EC (EC Machinery Directive). • Directive 94/9/EC of the European Parliament and of the Council of 23 March 1994 on the approximation of the laws of the Member States concerning equipment and protective systems intended for use in potentially explosive atmosphere (EC ATEX Directive). • Bergverordnung zum gesundheitlichen Schutz der Beschäftigten (Gesundheitsschutz-Bergverordnung, GesBergV) vom 31. Juli 1991. Hrsg. vom Bundesminister für Wirtschaft, Stand: 10. August 2005. 8. Auflage, Essen, VGE-Verlag, 2006. • Safety and health in underground coal mines. ILO code of practice. International Labour Office, Geneva, 2009. • Hermülheim, W. et al.: Handbuch für das Grubenrettungswesen im Steinkohlenbergbau (Colliery Mine Rescue Handbook, in

	German). Essen, VGE-Verlag, 2007. • Hermülheim, W./ Schumachers, R./ Dauber, C.: Occupational Health and Safety and Hazard Control in Coal Mines. Safety Projects in Countries in Transition to Industrialization – Part 1: Fundamentals of Mine Safety and Hazard Control. Glückauf Mining Reporter I/ May 2009, S. 38/42. • Hermülheim, W./ Schumachers, R./ Dauber, C.: Occupational Health and Safety and Hazard Control in Coal Mines. Safety Projects in Countries in Transition to Industrialization – Part 2: Safety Management Systems, Safety Training and Pilot Projects. Glückauf Mining Reporter III/ Oct. 2009, S. 44/48. • Martens, P. N./ Hermülheim, W.: Disaster Prevention in Deep Hard Coal Mining – a German Review. SME Annual Meeting, Phoenix, AZ, 2010, 308/13. • Darling, P. (Editor): SME Mining Engineering Handbook. 3. Edition, Part 15: Health and Safety. Society for Mining, Metallurgy and Exploration, Inc. (SME), 2011, P. 1557/1642. Additional selected literature on mine safety, e. g. regulations, conference papers, and mine rescue handbooks/ training materials available online: esb.bezreg-arnsberg.nrw.de www.workplacesafetynorth.ca www.cdc.gov/niosh www.hse.gov.uk www.cdc.gov/niosh/mining/ www.msha.gov (www.msha.gov/fatals/fabc.htm) www.qldminingsafety.org.au/ www.qmrs.com.au/resources/ www.coalservices.com.au/mining/mines-rescue/ www.industry.gov.au/resource/Mining/Pages/default.aspx www.resourcesandenergy.nsw.gov.au/miners-and-explorers/safety-and-health/publications/workbooks www.ilo.org/global/industries-and-sectors/mining/lang--en/index.htm www.bgrci.de/fachwissen-portal/themenspektrum/gefaehrdungsbeurteilung/ medienshop.bgrci.de/shop/ For basics of industrial OSH management systems in general, start at Wikipedia (English) and go for "OSHAS 18001" and "ISO 45001"
22b. Other	Course Outline: • Legal framework of occupational safety and health (OSH), safety and health documents, OSH management systems, hazard identification, risk assessment and control. • General physical, chemical, safety and ergonomic hazards. • Respirable dust. • Rock bursts, inrushes of water, gas outbursts.* • Mine fires, methane and flammable coal dust.* • Electricity, machinery and plant equipment.* • Explosives and shotfiring.*

	• Hoisting, haulage and transport.* • Roof and rock stability.* • Mine gases and mine ventilation.* • Emergency control.* • Safety competence, education and training, work organization. • Personal protective equipment (PPE). • Sources for Occupational Exposure Limits (OELs). • Health and hygiene issues, surveillance of the working environment. • Group exercise: Basics of risk analysis. (*) Topics are covered as to their safety aspects only but are dealt with mainly or completely in other lectures of the Master program.

Assessment					
23. No.	24. Respective Lecture	25. Type	26. LP	27. Grading	28. Emphasis
1	Responsible Mine Planning	MTP	3	graded	45%
2	Tutorial for Responsible Mine Planning	MTP	1	graded	20 %
3	Underground Mine Safety	MTP	2	graded	35 %

On No. 1: Underground Mine Planning	
29a. Type of Assessment	Written Examination (120 min)
30a. Examiner	Univ.-Prof. Dr.-Ing. Oliver Langefeld
31a. Compulsory Prerequisite for Exam	

On No. 2: Tutorial for Responsible Mine Planning	
29b. Type of Assessment	Marked Project
30b. Examiner	Univ.-Prof. Dr.-Ing. Oliver Langefeld
31b. Compulsory Prerequisite for Exam	-

On No. 3: Underground Mine Safety	
29b. Type of Assessment	Written exam (60 min)
30b. Examiner	Sandra Nowosad, M.Sc.
31b. Compulsory Prerequisite for Exam	-

1. Title of Module

Advanced Surface Mining

2. Integrated in following Study programs

M.Sc. Mining Engineering

3. Responsible Person for the module	4. Responsible Faculty for the module	5. Number of the Module
Univ.-Prof. Dr.-Ing. habil. Tudeshki	Faculty of Energy and Economic Sciences	11

6. Language	7. LP	8. Duration	9. Offering
English	8	[X] 1 Semester [ ] 2 Semester	[ ] every semester [X] every year [ ] inconstant

10. Learning objectives / Skills

After taking the lecture Surface Drilling Technology, the student has deep knowledge on

- technical parameters of mining related drilling technologies, e.g. for exploration, blasting, dewatering, pipe-laying
- comparison of alternative drilling technologies
- drilling requirements for the intended usage of the drill hole

and is able to

- evaluate a drilling task
- compare alternative drilling technologies
- and finally choose the optimum technology

After taking the lecture Advanced Surface Mining, the student has deep knowledge on

- principles and stages of surface mine planning
- computer-based open pit design
  - slope, bench and road construction
  - medium- and short-term production planning and scheduling
  - feasibility and economic assessments

and is able to

- check and verify input parameters, e.g. block model, pit limits, ultimate pit shell
- design an open pit
- analyse and optimize mine planning
- create maps, sections and reports to display planning results

Courses						
11. No.	12. Course title	13. Lecturer	14. Course No.	15. Course type	16. SWS	17. Workload Contact hours- / Self-Study time
1	Surface Drilling Technology	Univ.-Prof. Dr.-Ing. habil. Tudeshki	S 6078	V + Ü	2	20 h / 40 h
2	Introduction to Surface Mine Planning		W 6083	V + Ü	2	28 h / 62 h
3	Advanced Surface Mining		W 6069	V + Ü	2	28 h / 62 h
				Sum:	6	76 h / 164 h

On No. 1: Surface Drilling Technology	
18a. Suggested requirements	-
19a. Objectives	Students learn the technological principles of the most important drilling systems related to surface mining as well as the proposed utilization of the drill holes.
20a. Media	Lecture, projector-presentation, lecture notes, mine planning software
21a. Literature	Announcement in the lecture
22a. Other	• Course Outline: o General Drilling Basics o Blasthole Drilling / Blasting Technologies o Exploration Drilling / Data Analysis and Reporting o Water Well Drilling / Well Completion and Dewatering Systems o Horizontal Directional Drilling and Microtunneling / Pipe Laying • Drilling Simulator Software: Tutorial / Homework

On No. 2: Introduction to Surface Mine Planning	
18b. Suggested requirements	• Module 4 Economic Geology: o Geostatistics o Economic Geology
19b. Objectives	As software-based mine planning is one of the most important skills required by mining companies and often daily work a mining engineers, the use of a surface mine planning software will be introduced to the students. Based on fundamental knowledge of strategic mine panning and guided by lectures students will learn to set up a mining project and check the related data sets. Tutorials will strengthen the competence by guided self-practice.
20b. Media	Lectures, Software-based lectures and exercises
21b. Literature	Announcement in the lecture

22b. Other	Course Outline:
	• Introduction lectures
	  ○ Strategic surface mine planning
	  ○ Introduction to open pit design
	  ○ Data type and database
	  ○ Mine planning targets
	  ○ Optimization concepts
	  ○ Selection criteria
	• Software-based lectures
	  ○ Introduction to Surface Mine planning software
	  ○ Data import, e.g. geological model, ultimate pit
	  ○ Data check and evaluation
	• Accompanying tutorial for self-practice

On No. 3: Advanced Surface Mining	
18b. Suggested requirements	• Module 11: Advanced Surface Mining ○ Introduction to Surface Mine Planning
19b. Objectives	Based on sound theoretical knowledge, the students will execute a software-based open pit planning by themselves, learn to analyse alternative mine designs by different criteria and report the planning results. Tutorials will strengthen the competence by guided self-practice.
20b. Media	Lectures, Software-based lectures and exercises
21b. Literature	Announcement in the lecture

22b. Other	Course Outline:
	• Software-based lectures with integrated exercises
	  ○ Software structure and planning stages
	  ○ Slope, bench and road construction
	  ○ Automatic and manual pit design
	  ○ Dump volume calculation
	  ○ Determination of dump location and area
	  ○ Operational scheduling
	  ○ Evaluation of planning results
	  ○ Documentation and reporting
	• Accompanying tutorial for self-practice

Assessment					
23. No.	24. Respective Lecture	25. Type	26. LP	27. Grading	28. Emphasis
1	Surface Drilling Technology	MTP	2	graded	25 %
2	Introduction to Surface Mine Planning Advanced Surface Mining	MTP	6	graded	75 %

On No. 1: Surface Drilling Technology	
29. Type of Assessment	Written Examination (max. 60 min)
30. Examiner	Univ.-Prof. Dr.-Ing. habil. Tudeshki
31. Compulsory Prerequisite for Exam	-

On No. 2: Introduction to Surface Mine Planning / Advanced Surface Mining	
29. Type of Assessment	Marked project, presentation, colloquium
30. Examiner	Univ.-Prof. Dr.-Ing. habil. Tudeshki
31. Compulsory Prerequisite for Exam	-

1. Title of Module

Applied Rock Mechanics

2. Integrated in following Study programs			
M.Sc. Mining Engineering			
3. Responsible Person for the module Dr.-Ing. R. Wolters-Zhao		4. Responsible Faculty for the module Faculty of Energy and Economic Sciences	5. Number of the Module 12
6. Language English	7. LP 6	8. Duration [X] 1 Semester [ ] 2 Semester	9. Offering [ ] every semester [X] every year [ ] inconstant

10. Learning objectives / Skills

After taking the lecture and the tutorial, the student

has deep knowledge on

- Geomechanical design in case of room and pillar mining
- Geomechanical design in case of hard rock caverns as well as salt caverns
- Geomechanical design in case of rock slopes / open pit mines
- Geomechanical design in case of tunnels in weak rocks

and is able to

- estimate static stability of load bearing elements (pillar, roof, bottom floor) in different mining areas
- estimate appropriate support if demanded based on calculation results
- estimate surface subsidence as well as risk of cave to surface
- handle proofs earth static (sliding, slope stability, hydrostatic uplift, ground break, overturning, settlement)

Courses

11. No.	12. Course title	13. Lecturer	14. Course No.	15. Course type	16. SWS	17. Workload Contact hours- / Self-Study time
1	Applied Rock Mechanics	Dr.-Ing. R. Wolters-Zhao	W 6237	V	2	28 h / 62 h
2	Tutorial for Applied Rock Mechancis		W 6238	V	2	28 h / 62 h
				Sum:	4	56 h / 124 h

On No. 1+2: Applied Rock Mechanics Module

18. Suggested requirements	-

19. Objectives	Geomechanical design in room and pillar mining (pillar design, roof design, support by rock bolts and props) Cavern design (in case of elastic, plastic and viscous ground conditions taken into account demands on support, subsidence and risk of cave to surface) Rock slope stability considering six different proofs of earth static (sliding, slope stability, settlement, hydrostatic uplift, ground break, overturning) Tunnel design in weak rock (comparison between rock mass loading and strength of rock mass, deformation analysis, determination of critical strain, estimation of demanded support capacity)
20. Media	Projector-based presentation, lecture notes, exercises, experimental equipment
21. Literature	/1/ Jonson, R.B; DeGraff, J.V. (1988): Principles of Engineering Geology, Wiley. /2/ Kehew, A. E. (1995): Geology for Engineers & Environmental Scientists, Prentice Hall, 2nd. Ed. /3/ Biniawski, Z.T. (1984): Rock mechanics design in mining and tunneling, A.A. Balkema, Rotterdam, Boston. /4/ Brady, B.H.G.; Brown, E.T. (1985): Rock mechanics for underground mining, London, Georg, Allen & Unwin. /5/ Barton, N., Lien, R., Lunde, J.(1974): Engineering Classification of Rock Masses for the Design of Tunnel Support, Rock Mechanics 6, S. 189-236. /6/ Dobrin, M.B. (1976): Introduction to Geophysical Prospecting. Third edition, McGraw-Hill Book Company. /7/ Woods, R.D. (1994): Geophysical Characterization of Sites. Volume prepared by the International Society for Soil Mechanics and Foundation Engineering, (ISSMFE), Technical Committee No. 10 for the XIII. International Conference of Soil Mechanics and Foundation Engineering, (ICSMFE), New Dehli, India. /8/ E. Hoek; E.T. Brown (1980): Underground Excavations in Rock, The Institution of Mining and Metallurgy, London, ISBN 0 900488 54 9. /9/ T. H. Hanna (1973): Foundation Instrumentation, Trans Tech Publications, ISBN 0-878849-006-x. /10/ T. H. Hanna (1985): Field Instrumentation in Geotechnical Engineering, Trans Tech Publications, ISBN 0-87849-054-X. /11/ ASTM Designation D4645-87: Standard test method for determination of the in-situ stress in rock using the hydraulic fracturing method, Annual Book of ASTM Standards, 4.08, 851-856 (1989). /16/ R.K. Miller (1987): Nondestructive Testing Handbook, 2nd. edition, Volume 5, Acoustic Emission Testing, 1987, American Society for Nondestructive Testing, Columbus, OH. /17/ Lux, K.-H.; Hou, Z.; Düsterloh, U.; Xie, Z. (2000): Approaches for Validation and Application of A New Material Model for Rock Salt Including Structural Damages, Proceedings of 8th World Salt Symposium, Hague.

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/19/ Wolters, R.; Lux, K.-H.; Düsterloh,U. (2012): Evaluation of rock salt barrieres with respect to tightness: Influence of thermomechanical damage, fluid infiltration and sealing/healing, Mechanical Behaviour of Salt VII, Balkema

/20/ Düsterloh, U.; Lerche, S.; Lux, K.-H. (2013): Damage and Healing Properties of Rock Salt: Long-Term Cyclic Loading Tests and Numerical Back Analysis, In: Clean Energy Systems in the Subsurface: Production, Storage and Conversion - Proceedings of the 3rd Sino-German Conference "Underground Storage of CO2 and Energy, Goslar, 21-23 May 2013, Springer Series in Geomechanics & Geoengineering, ISBN 978-3-642-37848-5.

/21/ Düsterloh, U., Lux, K.-H. (2014): Improved lab tests for cavern design, ARMA 14-7009, Minneapolis.

/22/ Cristescu, N.; Hunsche, U. (1998): Time Effects in Rock Mechanics, John Wiley & Sons, Chichester, ISBN 0471 955175.

/23/ Proceedings of the 6th conference on the mechanical behaviour salt, saltmech 6 (2007): The Mechanical behaviour of salt - understanding of THMC processes in salt, Taylor & Francis.

/24/ Fossum, A. F.; Fredrich, J. T. (2002): Salt mechanics primer for near-salt and sub-salt deepwater gulf of mexico field developments, Sandia National Laboratories, Sandia Report SAND2002-2063.

/25/ Rusnack, J.; Mark, C.: Using the point load test to determine the uniaxial compressive strength of coal measure rock, National Institute for Occupational Safety and Health, Pittsburgh.

/26/ ISRM. International Society of Rock Mechanics Commission on Testing Methods, Suggested Method for Determining Point Load Strength, Int. J. Rock Mech. Min. Sci. and Geomech. Abstr. 22, 1985, pp.51-60.

/27/ Brown, E.T.; Hoek, E. (1978): Trends in relationship between measured rock in situ stresses and depth, Int. J. Rock Mech. Min. Sci. & Geomech.. Abstr. 15, pp. 211 - 215.

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/29/ Herget, G. (1988): Stresses in rock, A.A. Balkema, Rotterdam, Brookfield.

/30/ Zienkiewics, O.C. (1992): Finite Element Method.

/31/ Konietzky, H. (2004): Numerical modelling of discrete materials, Taylor & Francis.

/32/ Jing, (2007): Fals of discrete element methodes for rock engineering, Elsevier.

/33/ Andrieux, P. et.al. (2003): FLAC and numerical modelling in geomechanics 2003, Taylor & Francis.

22. Other	♦ Course Outline: • Design in room and pillar mining (pillar design, roof design, support and reinforcement by rock bolts and props) • Cavern design in case of elastic and plastic ground conditions (rock mass classification, rock mass properties, stresses and strains in excavation vicinity, support requirements, impact on surface) • cavern design in case of viscous ground conditions (rock mass properties, stresses and strains in excavation vicinity, min. and max. allowable cavern inside pressure, surface subsidence) • Slope stability • Proof of earth static analysis (settlement, slide stability, slope stability, hydrostatic uplift, ground break, overturning)

Assessment					
23. No.	24. Respective Lecture	25. Type	26. LP	27. Grading	28. Emphasis
1	Applied Rock Mechanics	MP	6	graded	100 %
2	Tutorial for Applied Rock Mechanics				
On No. 1+2: Applied Rock Mechanics Module					
29. Type of Assessment	Written Examination (120 min)				
30. Examiner	Dr.-Ing. R. Wolters-Zhao				
31. Compulsory Prerequisite for Exam	-				

1. Title of Module

Mining Engineering Seminar

2. Integrated in following Study programs			
M.Sc. Mining Engineering			
3. Responsible Person for the module Univ.-Prof. Dr.-Ing. Oliver Langefeld		4. Responsible Faculty for the module Faculty of Energy and Economic Sciences	5. Number of the Module 13
6. Language English	7. LP 6	8. Duration [X] 1 Semester [ ] 2 Semester	9. Offering [ ] every semester [X] every year [ ] inconstant

10. Learning objectives / Skills

After taking this module, the student

has deep knowledge on

- finding literature in online databases
- the challenges of stakeholder communication

and is able to

- conduct a thorough literature research
- interpret scientific literature
- process the information from literature in an appropriate way regarding the aim of research
- to write a well-structured report on a given task
- communicate the results of research to different stakeholders

Courses

11. No.	12. Course title	13. Lecturer	14. Course No.	15. Course type	16. SWS	17. Workload Contact hours- / Self-Study time
1	Mining Engineering Seminar	Professors involved in the Master-program Mining Engineering	S 6074	S	3	28 h / 122 h
2	Literature research, writing and presenting	Univ.-Prof. Dr.-Ing. Oliver Langefeld	S 6995	Ü	1	14 h / 16 h
				Sum:	4	42 h / 138 h

On No. 1: Seminar Mining Engineering	
18a. Suggested requirements	-
19a. Objectives	The Goal of this Seminar is to give the students a deeper understanding of the topics of the compulsory lectures as well as gaining an insight on current research areas and topics. The Module aims to improve the student's skills, to read and interpret scientific literature and to summarize own research results in a written report and to present the results in an oral presentation to an audience. The reading, understanding and summarizing skills learned during this course will help the students while working on their Master Thesis.
20a. Media	Thorough literature research
21a. Literature	General Literature to introduce the topic will be given by the supervisor when the Seminar begins
22a. Other	♦ Course Outline: • Topics according to the lectures of the Master Mining Engineering
On No. 2: Literature research, writing and presenting	
18b. Suggested requirements	-
19b. Objectives	To archive the aim of the Seminar Mining Engineering Module, students need to be able to perform a thorough literature research on their topic. In this workshop-based lecture, the most common as well as specialized databases for literature research will be shown; also, strategies on how to perform a targeted search within these databases are discussed. Furthermore, this lecture focuses on stakeholder communication: What is my target group, which information and which level of depth do I present, and how can I reach my target group. These points are discussed for written as well as presented information.
20b. Media	Workshop-based lecture, online literature catalogues
21b. Literature	-
22b. Other	

Assessment					
23. No.	24. Respective Lecture	25. Type	26. LP	27. Grading	28. Emphasis
1	Mining Engineering Seminar	MP	6	graded	100%
2	Literature research, writing and presenting	PV			

On No. 1: Mining Engineering Seminar	
29a. Type of Assessment	Written Thesis (max. 25 pages), oral presentation (about 20 minutes) and participation in the discussion following the presentation.
30a. Examiner	Professors involved in the Master program Mining Engineering
31a. Compulsory Prerequisite for Exam	Participation in “Literature research, writing and presenting”
On No. 2: Literature research, writing and presenting	
29b. Type of Assessment	Certificate of Participation
30b. Examiner	Univ.-Prof. Dr.-Ing. Oliver Langefeld
31b. Compulsory Prerequisite for Exam	--

1. Title of Module

Research Project

2. Integrated in following Study programs			
M.Sc. Mining Engineering			
3. Responsible Person for the module Univ.-Prof. Dr.-Ing. Oliver Langefeld		4. Responsible Faculty for the module Faculty of Energy and Economic Sciences	5. Number of the Module 14
6. Language English	7. LP 6	8. Duration [ ] 1 Semester [X] 2 Semester	9. Offering [X] every semester [ ] every year [ ] inconstant

10. Learning objectives / Skills

The Student Research Project gives the students the possibility to intensify their knowledge of the topics discussed in the lectures as well as to get an insight into current research topics. Besides the technical skills required to do so, the students will have a chance to improve their soft skills, as the project offers them a platform for progress reporting, testing and sharing of ideas and group discussions on the way forward.

Courses

11. No.	12. Course title	13. Lecturer	14. Course No.	15. Course type	16. SWS	17. Workload Contact hours- / Self-Study time
1	Student Research Project	Professors involved in the Masterprogram Mining Engineering	W 6075	S	4	5 h / 175 h
				Sum:	4	5 h / 175 h

On No. 1: Student Research Project

18. Suggested requirements	Seminar Mining Engineering

19. Objectives	The Student Research Project gives the students the possibility to intensify their knowledge of the topics discussed in the lectures as well as to get an insight into current research topics. Besides the technical skills required to do so, the students will have a chance to improve their soft skills, as the project offers them a platform for progress reporting, testing and sharing of ideas and group discussions on the way forward.
20. Media	Written Thesis, Presentation
21. Literature	General Literature will be given by the supervisor when the Student Research Project begins.
22. Other	♦ Course Outline: • Topics according to the lectures of the Master Mining Engineering ♦ A student research project can be given by all professors involved in the curriculum. It is possible to do it at university or as industry-based project.

Assessment					
23. No.	24. Respective Lecture	25. Type	26. LP	27. Grading	28. Emphasis
1	Research Project	MP	6	graded	100%

On No. 1: Research Project	
29. Type of Assessment	Written Thesis
30. Examiner	Professors involved in the Master program Mining Engineering
31. Compulsory Prerequisite for Exam	-

1. Title of Module
Master Thesis

2. Integrated in following Study programs			
M.Sc. Mining Engineering			
3. Responsible Person for the module Univ.-Prof. Dr.-Ing. Oliver Langefeld		4. Responsible Faculty for the module Faculty of Energy and Economic Sciences	5. Number of the Module 15
6. Language English	7. LP 24	8. Duration [X] 1 Semester [ ] 2 Semester	9. Offering [X] every semester [ ] every year [ ] inconstant
10. Learning objectives / Skills During the Master Thesis the students can apply their Mining Engineering knowledge to a specific problem or research topic. This gives the student the possibility to show, that he has learned to work independently on complex scientific topics, approach the topic in a well-structured and scientific manner and express the results in a written report. Additionally, the students can prove that they are able to present their results to an audience during a presentation which includes a follow-up discussion with the audience.			

Courses						
11. No.	12. Course title	13. Lecturer	14. Course No.	15. Course type	16. SWS	17. Workload Contact hours- / Self-Study time
1	Master Thesis	Professors involved in the Masterprogram Mining Engineering		MA	14	720
				Sum:	14	720

On No. 1: Master Thesis	
18. Suggested requirements	Admission according to § 11 Absatz 4 of the „Allgemeine Prüfungsordnung" (APO).

19. Objectives	During the Master Thesis the students can apply their Mining Engineering knowledge to a specific problem or research topic. This gives the student the possibility to show, that he has learned to work independently on complex scientific topics, approach the topic in a well-structured and scientific manner and express the results in a written report. Additionally, the students can prove that they are able to present their results to an audience during a presentation which includes a follow-up discussion with the audience.
20. Media	Written thesis, oral presentation.
21. Literature	General Literature will be given by the supervisor when the Master Thesis begins.
22. Other	♦ Course Outline: • Topics according to the lectures of the Master Mining Engineering ♦ A topic for the Master Thesis can be given by all professors involved in the curriculum. It is possible to do it at university or in industry.

Assessment

23. No.	24. Respective Lecture	25. Type	26. LP	27. Grading	28. Emphasis
1	Master Thesis	Ab	24	graded	80%
2	Master Thesis Presentation			graded	20%

On No. 1&2: Master Thesis

29. Type of Assessment	Written Thesis and an oral presentation of the results with following discussion
30. Examiner	Professors involved in the Master program Mining Engineering
31. Compulsory Prerequisite for Exam	-

1. Title of Module

Specialized Driving Methods

2. Integrated in following Study programs			
M.Sc. Mining Engineering			
3. Responsible Person for the module Univ.-Prof. Dr.-Ing. Oliver Langefeld		4. Responsible Faculty for the module Faculty of Energy and Economic Sciences	5. Number of the Module 16.1
6. Language English	7. LP 3	8. Duration [X] 1 Semester [ ] 2 Semester	9. Offering [ ] every semester [X] every year [ ] inconstant

10. Learning objectives / Skills

After taking the lecture and the tutorial, the student
has deep knowledge on

- Application of geomechanical methods for support design
- Underground stress field and influence by depth and mining activities
- Rock mass classification
- Calculation of roadway convergence for underground mines

and is able to

- apply geotechnical rock mass classification
- calculate a safety factor for support systems
- select roadway development methods and equipment
- compose measurement systems and monitoring instrumentation

Courses

11. No.	12. Course title	13. Lecturer	14. Course No.	15. Course type	16. SWS	17. Workload Contact hours- / Self-Study time
1	Specialized Driving Methods	Dr. Holger Witthaus	S 6196	V	2	28 h / 62 h
				Sum:	2	28 h / 62 h

On No. 1: Specialized Driving Methods

18. Suggested requirements	-

19. Objectives	This course is intended to provide treatment for a sufficient roadway support design for the driving and utilization phase at great mining depths. The topics would focus on practice-orientated engineering perspectives and take the complete roadway lifecycle into account. The following topics will be treated: ♦ Fundamental knowledge and practical application in geotechnical and geomechanical principles of strata and benefits of the rock mass classification. ♦ The effect of depth-related stress and additional load generated stress from mining activities and on the prediction of roadway convergence in consideration of geomechanical evaluations. ♦ Selection of the roadway development methods and mechanical equipment. ♦ Roadway support systems and elements, with emphasis on rock bolt applications as well as cementitious construction materials and techniques, and process of grout/resin injection. ♦ Structured roadway planning process and support calculation methods. Functionality of various measuring and roadway monitoring instruments during development and use in frame of ground control.
20. Media	Oral presentation with projector support
21. Literature	♦ Junker M., Lemke M. (2018) Technical developments in coal mining, Vulkan Verlag, Essen ♦ Junker M., Imgenberg D. (2017) Technikentwicklung in der Vorleistung, GeoRecources Verlag, Duisburg ♦ Wittke W. (2014) Rock Mechanics Based on an Anisotropic Jointed Rock Model (AJRM). 900 p., Wiley ♦ Pariseau W. G. (2011) Design Analysis in Rock Mechanics, Second Edition. 698 p., CRC Press; 2 Edition ♦ Junker M., et al. (2009) Strata control in in-seam roadways. 648 p., Verlag Glückauf GmbH, Essen ♦ Peng S.S. (2008) Coal Mine Control. 750 p., Dep. of Mining Engineering and Mineral Resources, Morgantown (WV) ♦ Hoek E. (2007) Practical Rock Engineering. Downloadable at: https://www.rocscience.com/education/hoeks_corner ♦ Witthaus H., Polysos N (2007) Rock Mass Classification in German Hard- Coal mining: Standards and Application Proceedings of the International Workshop on Rock Mass Classification in Underground Mining. In Mark, C., R., Pakalnis, R. J., Tuchman: NIOSH Publications No 2007-128, IC 9498, Pittsburg ♦ Brady, H.G Barry, E.T Brown. (2004) Rock Mechanics for underground mining. 626 p., Springer,3rd edition., XVIII ♦ Spearing A.J.S. (1995) Handbook on Strata Control. 146 p., CTP, Cape Town

22. Other	♦ Course Outline: • Geotechnical principles of strata control • Rock stress and stress field in multiple seam mining • Rock and roadway deformation • Heading and support systems • Roadway development and support design methods and calculations • Roadway monitoring

Assessment					
23. No.	24. Respective Lecture	25. Type	26. LP	27. Grading	28. Emphasis
1	Specialized Driving Methods	MP	3	graded	100%

On No. 1: Specialized Driving Methods	
29. Type of Assessment	Written examination (60 min)
30. Examiner	Dr. Holger Witthaus
31. Compulsory Prerequisite for Exam	-

1. Title of Module

Underground Blasting and Explosives Engineering

2. Integrated in following Study programs			
M.Sc. Mining Engineering			
3. Responsible Person for the module Univ.-Prof. Dr.-Ing. Oliver Langefeld		4. Responsible Faculty for the module Faculty of Energy and Economic Sciences	5. Number of the Module 16.3
6. Language English	7. LP 3	8. Duration [X] 1 Semester [ ] 2 Semester	9. Offering [ ] every semester [X] every year [ ] inconstant

10. Learning objectives / Skills

After taking the lecture and the tutorial, the student
has deep knowledge on

- comparing and selecting civil explosives by their classification, properties and performance
- recognizing blasting methods, planning, and designing underground drill and blast rounds
- establishing and managing legal requirements, safety and security awareness in explosives application
- assessing and evaluating underground blast design and emission reduction

and is able to

- select the suitable patterns, explosives and initiation devices for specific tasks
- design and calculate underground blast rounds including the appropriate delay pattern
- determine and apply the appropriate legal, safety and security conditions for underground blasting

Courses

11. No.	12. Course title	13. Lecturer	14. Course No.	15. Course type	16. SWS	17. Workload Contact hours- / Self-Study time
1	Underground Blasting and Explosives Engineering	Dr.-Ing. Rüdiger Triebel	S 6230	V	2	28 h / 62 h
				Sum:	2	28 h / 62 h

On No. 1: Underground Blasting and Explosives Engineering	
18. Suggested requirements	Basics knowledge about underground mining methods and mining processes.
19. Objectives	♦ At the conclusion of the lecture, participants will be able to recognize, describe, classify, analyze, and to develop underground drill and blast methods and procedures. Therefore, historic data, basic terms and definitions and the according legal framework are explained and discussed. Students will be able to recall the classifications of civil explosives and initiation systems and to relate to the demonstrations with regard to the nature and the properties of modern civil explosives, initiation systems, and blasting accessories used in the mining industry. ♦ Participants will be able to give examples of suitable explosives supply, logistics and application, they will be able to determine measures for best practice in underground blasting, cost optimization and reduction of blast emissions. ♦ Furthermore, participants will be able to classify, design, plan and calculate underground drill and blast patterns in development, extraction and shaft sinking regarding the appropriate drill pattern, explosives and initiation selection. Therefore, the development and the application of different underground blasting methods is discussed and diagnosed during the lectures, multiple relevant underground drill and blast design examples are analyzed and evaluated. ♦ Finally, participants will be able to establish the required specific safety and security awareness in explosives logistics and application and will be able to compare, assess, evaluate and propose suitable options for the reduction of underground blast emissions.
20. Media	Presentations, basic calculations, demonstrations, case-study and instructional videos.
21. Literature	♦ Albrecht, T.; Triebel, R.: Die elektrische Zündtechnik im deutschen Kali- und Steinsalz-Bergbau; Nobel Hefte 73/74; 2007/2008, Seite 173-178. ♦ Apel/Keusgen: Sprengstoffgesetz; Loseblattwerke Carl Heymanns Verlag KG; Stand 2014. ♦ Bauer, J.; Bornheim, W.: Die technische Entwicklung von der manuellen zur automatisierten Zünderfertigung in der Züfa Troisdorf; Nobel Hefte 73/74; 2007/2008, Seite 127-140. ♦ Bergbau-Forschung GmbH: Verbesserte Technik und Organisation im Sprengvortrieb, EKGS-EWG-EAG, Brüssel, Luxemburg; 1990. ♦ Breidung, K. P.: Im Mittelpunkt Sprengstoff; MSW-Chemie GmbH; 1999. ♦ Deutsche Gesetzliche Unfallversicherung e.V. : BGR/GUV-R 241 Regel Sprengarbeiten; Berlin; 2012.

- DIN 20163, Sprengtechnik, Begriffe, Einheiten Formelzeichen; Beuth Verlag GmbH, Berlin; 1994.
- Dyno Nobel: Blasting and Explosives Quick Reference Guide; 2010; http://www.lic.wisc.edu/glifwc/Polymet/SDEIS/references/Dyno%20Nobel%202010.pdf
- Fornefeld, M.: Grundsätzliche Untersuchungen zur sprengtechnischen Herstellung großräumiger Deponiekammern im Steinsalzgebirge; Dissertation TU Clausthal; Clausthal 1988.
- Grothe, D.; Hammelmann, F.: Das nichtelektrische Zündsystem EXEL; Nobel Hefte 73/74; 2007/2008, Seite 217-223.
- Hammelmann, Albrecht: Gewerbliche Sprengmittel bei untertägigen Sprengarbeiten, Nobel Hefte 2006, Seite 9-18
- Hammelmann, F.: i-kon™ - Das elektronische Zündsystem von Orica; Nobel Hefte 73/74; 2007/2008, Seite 204-207.
- Hammelmann, F; Reinders, P.; Vogel, G: Zündtechnik im Wandel der Zeit – Gestern, Heute und Morgen; Nobel Hefte 73/74; 2007/2008, Seite 6-26.
- Hammelmann, F; Schneider, H.; Staskiewicz, L; Straeten, T.: Sprengstoffe im Wandel der Zeit unter besonderer Betrachtung ihrer Leistungsbeurteilung; SprengInfo 27 (2005) 3, Seite 19-34.
- Heinze, H.: Sprengtechnik, Anwendungsgebiete und Verfahren; Deutscher Verlag für Grundstoffindustrie, Leipzig, Stuttgart; 1993.
- Held, M: Betrachtung von Leistungsdaten verschiedener Sprengstoffe; SprengInfo 27 (2005) 3, Seite 35-41.
- ISEE Blaster`s Handbook™; International Society of Explosives Engineers; Cleveland OH; 2011.
- Köhler, J.; Meyer, R.; Homburg, A.: Explosivstoffe; WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim; 2008.
- Krebs, H.; Vogel, G.: Die Stellung von U- und HU-Zündern in der Zünderklassifizierung (Klassen I bis IV) und die Auswirkungen für die Sprengpraxis; Sprenginfo 34, 2012 3, Seite 14-21.
- LHS Germany, Laden Sprengen Sicherheit 2014/2016; Nordheim v. d. Rhön; 2014.
- Lück, H.: Schießen mit neuen nitroglyzerinfreien AN-Sprengstoffen; Kali und Steinsalz, Band 4, Heft 1, 1964, Seite 1-8.
- Olofson, S. O.; Applied explosives technology for construction and mining; Applex AB, Ärla; 2002.
- Persson, P.-A.; Holmberg, R; Jaimin, L.: Rock blasting and explosives engineering; CRC Press, Boca Raton, London, New York, Washington D.C.; 1994.
- Roschlau, H.: Sprengen, Theorie und Praxis; Deutscher Verlag für Grundstoffindustrie; Leipzig, Stuttgart; 1993.
- Schillinger, R.: Sprengtechnik und Umwelt in der Praxis; Carl Hanser Verlag, München; 2009.
- Schwarz, S.: Messung toxischer Schwadenbestandteile von gewerblichen Sprengstoffen - Erste Ergebnisse; SprengInfo Nr. 3, 2005, Seite 33-38.

	♦ Spod, U: Überlagerung der NOx-Belastungen auf Baustellen unter Tage infolge Dieselmotoremissionen und Sprengbetrieb; NO2-Workshop des FAD e.V., München; 2006. ♦ Sprengtechnisches Handbuch; Dynamit Nobel Aktiengesellschaft; Troisdorf. ♦ Standing Working Group for Mining Industry of the Advisory Committee for Work Safety and Health Protection at European Commission: Code of good practice of shot-firer; Luxemburg; 2009. ♦ Staskiewicz, L.: Sprengstoffauswahl im Tunnelbau; Orica, Sprengtechnischer Dienst; 2006. ♦ Strasser, C. Erkurt, K; Hammelmann, F: Sprengarbeiten auf einer modernen Tunnelbaustelle; Nobel Hefte 2006, Seite 25-31. ♦ Vogel, G.: Zünden von Sprengladungen; Verlag Leopold Hartmann; Sondheim vor der Rhön; 2000. ♦ Wild, H.-W.: Sprengtechnik in Bergbau, Tunnel- und Stollenbau sowie in Tagebauen und Steinbrüchen; Verlag Glückauf GmbH, Essen; 1984.

♦ 22. Other	♦ Course Outline: • History of civil explosives • Terms and properties of civil explosives and initiation systems • Basics of underground blasting applications • Introduction into civil explosives regulations • Underground blasting methods • Reduction of blasting emissions • Safety and security aspects ♦ Excursions to underground mines and (depending on availability) to explosives manufacturers to learn about the practical aspects of civil explosives in drill and blast operations.

Assessment					
23. No.	24. Respective Lecture	25. Type	26. LP	27. Grading	28. Emphasis
1	Underground Blasting and Explosives Engineering	MP	3	graded	100%

On No. 1: Underground Blasting and Explosives Engineering	
29. Type of Assessment	Oral (45 min) or written examination (90 min).
30. Examiner	Dr.-Ing. Rüdiger Triebel
31. Compulsory Prerequisite for Exam	-

1. Title of Module

Natural Gas Storage in Rock Caverns

2. Integrated in following Study programs

M.Sc. Mining Engineering

3. Responsible Person for the module		4. Responsible Faculty for the module	5. Number of the Module
Dr.-Ing. S. Lerche		Faculty of Energy and Economic Sciences	16.4
6. Language	**7. LP**	**8. Duration**	**9. Offering**
English	3	[X] 1 Semester [ ] 2 Semester	[ ] every semester [X] every year [ ] inconstant

10. Learning objectives / Skills

After taking the lecture and the tutorial, the student

has deep knowledge on

- genesis, structure and location of salt deposits
- geotechnical characteristics of salt caverns
- geotechnical design and planning concepts for salt caverns
- rock salt material properties and constitutive laws to characterize rock salt mass
- analytical procedures to simulate the load bearing behaviour of salt caverns
- proof of safety in case of salt caverns
- basics to control operation in case of natural gas storage in salt caverns

and is able to

- determine geotechnical parameters for rock salt mass as well as parameters belonging to constitutive laws based on lab tests
- compute stress and strain in the rock mass surrounding gas storage caverns by using analytical solutions
- read, verify and validate numerically computed results to evaluate static stability and tightness of natural gas storage caverns

Courses

11. No.	12. Course title	13. Lecturer	14. Course No.	15. Course type	16. SWS	17. Workload Contact hours- / Self-Study time
1	Natural Gas Storage in Rock Caverns	Dr.-Ing. S. Lerche	S 6228	V	2	28 h / 62 h
				Sum:	2	28 h / 62 h

On No. 1: Natural Gas Storage in Rock Caverns	
18. Suggested requirements	Advanced Rock Mechanics
19. Objectives	Genesis, structure and location of salt deposits Geotechnical characteristics of salt caverns Geotechnical design and planning concepts Material properties and constitutive laws to characterize rock salt caverns Mathematical simulation of load bearing behaviour of salt caverns Geotechnical proof of safety in case of salt caverns Control of operation
20. Media	Lecture, projector presentation, lecture notes
21. Literature	/1/ Katz, D.; Lee, R.L.: Natural Gas Engineering – Production and Storage, McGraw-Hill Publ. Co., 1990. /2/ Düsterloh, U.; Lux, K.-H. (2005): Monitoring, Documentation & Calculation of Economically Optimized Operation Patterns of Gas Cavities using a Computer Aided Program, SMRI Fall Conference, Nancy, France. /3/ Lux, K.-H.; Wolters, R.; Düsterloh, U. (2006): Long Term Behaviour of Sealed Brine-filled Cavities in Rock Salt Mass – A new Approach for Physical Modelling and Numerical Simulation, SMRI Fall Conference, Rapid City, South Dakota. /4/ Wolters, R.; Lux, K.-H.; Düsterloh, U. (2010): Evaluation of Rock Salt Barriers with Respect to Tightness: Influence of Thermomechanical Damage, Fluid Infiltration and Sealing/Healing, American Rock Mechanics Association, ARMA 10-215. /5/ www.solutionmining.org → comprehensive data base containing almost the totality of salt cavern belonging publications
22. Other	♦ Course Outline: • Introduction, media for storage and operation principles • Gas storage in salt caverns: geological conditions, planning criteria for exploration and drilling, geomechanical conditions and design of caverns, thermodynamic conditions • Operation fundamentals: leaching techniques/control, completion, surface facilities, storage operation, capacity characteristics, optimization strategies • Field cases: selected examples • Storage of liquids in mined caverns

Assessment					
23. No.	24. Respective Lecture	25. Type	26. LP	27. Grading	28. Emphasis
1	Natural Gas Storage in Rock Caverns	MP	3	graded	100%

On No. 1: Natural Gas Storage in Rock Caverns	
29. Type of Assessment	Written examination (90 min).
30. Examiner	Dr.-Ing. S. Lerche
31. Compulsory Prerequisite for Exam	-

1. Title of Module

Computer-Based Block Modelling and Resource Estimation

2. Integrated in following Study programs			
M.Sc. Mining Engineering			
3. Responsible Person for the module Univ.-Prof. Dr.-Ing. habil. Tudeshki		4. Responsible Faculty for the module Faculty of Energy and Economic Sciences	5. Number of the Module 16.5
6. Language English	7. LP 3	8. Duration [X] 1 Semester [ ] 2 Semester	9. Offering [ ] every semester [X] every year [ ] inconstant

10. Learning objectives / Skills

After taking the lecture and the tutorial, the student has deep knowledge on

- resource estimation theory and standards
- data base creation, value assessment and verification
- geological model generation

and is able to

- fulfill computer-based geological data analysis and interpretation
- generate a digital resource model based on geostatistical methods
- work out a comprehensive and reliable report on reserves and resources

Courses

11. No.	12. Course title	13. Lecturer	14. Course No.	15. Course type	16. SWS	17. Workload Contact hours- / Self-Study time
1	Computer-Based Block Modelling and Resource Estimation (ASM II)	Univ.-Prof. Dr.-Ing. habil. Tudeshki	S 6066	V	2	30 h / 60 h
				Sum:	2	30 h / 60 h

On No. 1: Computer-Based Block Modelling and Resource Estimation (ASM II)

18. Suggested requirements	♦ Module 4 Economic Geology: • Geostatistics • Economic Geology

19. Objectives	Based on the theoretical knowledge from Module 4 Economic Geology students learn the fundamental steps of computer-based resource estimation by using the software Datamine Studio RM. The lectures and exercises cover all steps of deposit modelling, starting with the database of exploration results and ends with standardized reporting of reserves.
20. Media	Software-based lecture and exercises
21. Literature	Announcement in the lecture
22. Other	♦ Course Outline: • Introduction to resource estimation • Exploration data type and database • Drill hole database and compositing • Statistic data analysis / Geological interpretation • Orebody and block modelling / Geostatistical and various estimation methods • Resource classification • Resource and reserve reporting standards ♦ Lectures with integrated exercises ♦ Accompanying tutorial for self-practice

Assessment

23. No.	24. Respective Lecture	25. Type	26. LP	27. Grading	28. Emphasis
1	Computer-Based Block Modelling and Resource Estimation (ASM II)	MP	3	graded	100%

On No. 1: Computer-Based Block Modelling and Resource Estimation (ASM II)

29. Type of Assessment	Marked project, presentation, colloquium
30. Examiner	Univ.-Prof. Dr.-Ing. habil. Tudeshki
31. Compulsory Prerequisite for Exam	-

1. Title of Module

Computer-Based Surface Mine Planning

2. Integrated in following Study programs M.Sc. Mining Engineering			
3. Responsible Person for the module Univ.-Prof. Dr.-Ing. habil. Tudeshki		4. Responsible Faculty for the module Faculty of Energy and Economic Sciences	5. Number of the Module 16.6
6. Language English	7. LP 3	8. Duration [X] 1 Semester [ ] 2 Semester	9. Offering [ ] every semester [X] every year [ ] inconstant

10. Learning objectives / Skills

After taking the lecture and the tutorial, the student has deep knowledge on

- transfer of a geological model into a technical/economic model
- medium and long term surface mine planning
- determination of ultimate pit limits and minable reserves
- economic evaluation of by means von NPV calculations

and is able to

- execute computer-based medium and long term surface mine planning
- carry out a technical as well as economic evaluation of a surface mining project
- review evaluation results by a sensitivity analysis

Courses

11. No.	12. Course title	13. Lecturer	14. Course No.	15. Course type	16. SWS	17. Workload Contact hours- / Self-Study time
1	Computer-Based Surface Mine Planning (ASM III)	Univ.-Prof. Dr.-Ing. habil. Tudeshki	S 6067	V	2	45 h / 45 h
				Sum:	2	45 h / 45 h

On No. 1: Computer-Based Surface Mine Planning (ASM III)

18. Suggested requirements	♦ Module 2 International Mining: • International Mining • Mining and Finance ♦ Module 12 Advanced Surface Mining: • Advanced Surface Mining • Mining and Environment ♦ Module 18.5 Computer-Based Block Modelling and Resource Estimation (ASM II), (recommended!)
19. Objectives	Based on the theoretical knowledge from module 2 International Mining and module 12 Advanced Surface Mining students learn the fundamental steps of computer-based strategic surface mine planning by using the software Datamine NPV Scheduler.
20. Media	Software-based lecture and exercises Accompanying tutorial for self-practice
21. Literature	Announcement in the lecture
22. Other	• Course Outline: o Introduction to strategic surface mine planning o Definition of required data base o Data import, e.g. geological model o Setting up an economical model o Ultimate pit based on Lerchs-Grossmann algorithm o Pushback scheduling o Optimization of mining schedule: o Cut-off grade optimization o Cash flow maximization o NPV calculation o Sensitivity analysis

Assessment

23. No.	24. Respective Lecture	25. Type	26. LP	27. Grading	28. Emphasis
1	Computer-Based Surface Mine Planning (ASM III)	MP	3	graded	100%

On No. 1: Computer-Based Surface Mine Planning (ASM III)

29. Type of Assessment	Marked project, presentation, colloquium
30. Examiner	Univ.-Prof. Dr.-Ing. habil. Tudeshki
31. Compulsory Prerequisite for Exam	-

1. Title of Module

Underground Water Systems and Treatment

2. Integrated in following Study programs			
M.Sc. Mining Engineering			
3. Responsible Person for the module M. Bothe-Fiekert, M.Sc.		4. Responsible Faculty for the module Faculty of Energy and Economic Sciences	5. Number of the Module 16.7
6. Language English	7. LP 3	8. Duration [X] 1 Semester [ ] 2 Semester	9. Offering [ ] every semester [X] every year [ ] inconstant

10. Learning objectives / Skills

After taking the course, the student has knowledge on

- the basics of hydrogeology
- the design criteria for wells
- the design and calculation of pumps pipe-systems

and is able to

- design wells and well-systems and the pumping system needed

Courses

11. No.	12. Course title	13. Lecturer	14. Course No.	15. Course type	16. SWS	17. Workload Contact hours- / Self-Study time
1	Underground Water Systems and Treatment	M. Bothe-Fiekert, M.Sc.	W 6998	V	2	28 h / 47 h
				Sum:	2	28 h / 47 h

On No. 1: Underground Water Systems and Treatment

18. Suggested requirements	Basic knowledge in hydrodynamics
19. Objectives	♦ Participants of the course will be introduced into the basics of hydrogeology. They learn to design single wells and multiple well systems. In addition, the participants learn to design pumps and pipe systems. ♦ A study trip to the Kaiser-Wilhelm-Schacht is part of the lecture. Former mining technologies to pump groundwater are shown.

20. Media	Presentations, basic calculations, demonstrations, videos.
21. Literature	A table of literature will be given in the lecture.
22. Other	♦ Course Outline: • Basics of hydrogeology • Design of single wells • Design of multiple well systems • Design of pump systems • Calculation of water transport

Assessment					
23. No.	24. Respective Lecture	25. Type	26. LP	27. Grading	28. Emphasis
1	Underground Water Systems and Treatment	MP	3	graded	100%
On No. 1: Underground Water Systems and Treatment					
29. Type of Assessment	Written examination (90 min).				
30. Examiner	M. Bothe-Fiekert, M.Sc.				
31. Compulsory Prerequisite for Exam	-				

1. Title of Module

Sustainable Mine Practice

2. Integrated in following Study programs			
M.Sc. Mining Engineering			
3. Responsible Person for the module A. Binder, M.Sc.		4. Responsible Faculty for the module Faculty of Energy and Economic Sciences	5. Number of the Module 16.8
6. Language English	7. LP 3	8. Duration [X] 1 Semester [ ] 2 Semester	9. Offering [ ] every semester [X] every year [ ] inconstant

10. Learning objectives / Skills

After the module "Sustainable Mine Practice", the student is able to

- Explain the responsibility of Mining and support the role with fitting examples.
- Defend the role of mining in the circular economy.
- Explain the impact of Mining on its overall environment, critically review its measurement and give examples for the high and low impacts
- Identify stakeholders of mining activities and analyze their significance for given situations
- Describe future trends in mining and deduce required actions in given scenarios.
- Analyze and select mining methods and procedures regarding its impacts on safety, communities, environment, economics and resource efficiency.
- Explain the how a sustainable development can be fostered during the preproduction, production, closure and post-mining stage.
- Design actions to communicate the concern of mining effectively towards different stakeholder groups

Courses

11. No.	12. Course title	13. Lecturer	14. Course No.	15. Course type	16. SWS	17. Workload Contact hours- / Self-Study time
1	Sustainable Mine Practice	A. Binder, M.Sc.	W 6987	V	2	28 h / 62 h
				Sum:	2	28 h / 62 h

On No. 1: Sustainable Mine Practice	
18. Suggested requirements	♦ Basics of Underground Mining (Tiefbau 1/2) ♦ Responsible Mining
19. Objectives	♦ See No. 10
20. Media	Oral presentation and discussion (supported by analog and digital media) Personal Talk, Videos, paper and books
21. Literature	♦ Azapagic, A., 2004. Developing a framework for sustainable development indicators for the mining and minerals industry [online]. Journal of Cleaner Production, 12(6), 639-662. Available from: 10.1016/S0959-6526(03)00075-1 ♦ Franks, D.M., 2011. Management of Social Impacts of Mining. In: P. Darling, ed. SME mining engineering handbook. Englewood, Col.: SME - Soc. for Mining Metallurgy and Exploration, pp. 1817-1825. ♦ Hitch, M., 2018. Australia, Leading the Practice in Sustainable Mining. Mining Report, 154(1), 69-74. ♦ Hodge, R.A., 2011. Mining and Sustainability. In: P. Darling, ed. SME mining engineering handbook. Englewood, Col.: SME - Soc. for Mining Metallurgy and Exploration, pp. 1665-1688. ♦ International Finance Corporation, International Council on Mining and Metals, and Brunswick Group, 2015 / 06. Changing the game. communication & sustainability in the mining industry. ♦ International Organization for Standardization (ISO). ISO 14040:2006:2006, Environmental management -- Life cycle assessment -- Principles and framework. ♦ Jessup Bingham, E.L., 2011. Closure Planning. In: P. Darling, ed. SME mining engineering handbook. Englewood, Col.: SME - Soc. for Mining Metallurgy and Exploration, pp. 1753-1764. ♦ Kickler, K., 2018. Certification of Responsible Mining Practices and Mineral Supply Chains. Mining Report, 154(1), 33-37. ♦ Klopffer, W., 1997. Life cycle assessment: From the beginning to the current state [online]. Environmental science and pollution research international, 4(4), 223-228. Available from: 10.1007/BF02986351 ♦ Langefeld, O. and A. Binder, 2018. Responsible Mining. Mining Report, 154(1), 20-27. ♦ Laurence, D., 2011. Establishing a sustainable mining operation [online]. An overview. Journal of Cleaner Production, 19(2-3), 278-284. Available from: 10.1016/j.jclepro.2010.08.019 ♦ Mirande, M., D. Chamber, and C. Coumans, 2005. Framework for Responsible Mining. A Guide to Evolving Standards. ♦ Richards, J.P., 2009. Mining, society, and a sustainable world. Heidelberg: Springer. ♦ Sinding-Larsen, R. and F.-W. Wellmer, eds., 2012. Non-renewable resource issues. Geoscientific and societal challenges. Dordrecht: Springer. International year of planet earth. ♦ World Commission on Environment and Development, 1987. Our common future. Repr. Oxford: Oxford Univ. Press.

22. Other	♦ Course Outline: • Introduction to sustainable Mining, the future of Mining and its role in the circular economy • Sustainable Development in Mining • Pre-Mining: Planning for Responsible Mining • Impacts of Mining in Production • Sustainable Mining methods of the future • Shaping the footprint of Mining: Mine closure

Assessment					
23. No.	24. Respective Lecture	25. Type	26. LP	27. Grading	28. Emphasis
1	Sustainable Mine Practice	MP	3	graded	100%
On No. 1: Sustainable Mine Practice					
29. Type of Assessment	40% written assignment + 60% oral examination				
30. Examiner	A. Binder, M.Sc.				
31. Compulsory Prerequisite for Exam	-				

1. Title of Module

Mine Closure

2. Integrated in following Study programs			
MSc. Mining Engineering			
3. Responsible Person for the module Univ.-Prof. Dr.-Ing. Oliver Langefeld		4. Responsible Faculty for the module Faculty of Energy and Economic Sciences	5. Number of the Module 16.9
6. Language English	7. LP 3	8. Duration [X] 1 Semester [ ] 2 Semester	9. Offering [ ] every semester [X] every year [ ] inconstant

10. Learning Skills

After taking the lecture, the student has deep knowledge on

- The influencing factors and challenges of Mine Closure processes
- Design on Mine Closure Plans, in regard to different environments
- Technical, environmental, social and legal aspects of Mine Closure processes
- Communication strategies for different stakeholder groups

and is able to

- Plan the basic steps of Mine Closure process
- Identify influencing factors of a Mine Closure process
- Assess the relative risks for the whole process of each influencing factor
- Perform a stakeholder assessment and suggest communication strategies based on the results

Courses

11.No.	12. Course title	13. Lecturer	14. Course No.	15 Course type	16. SWS	17. Workload Contact hours- / Self-Study time
1	Mine Closure	S. Nowosad, M.Sc.	S 6988	V	2	28 h /62 h
				Sum:	2	28 h /62 h

On No. 1: Mine Closure

18. Suggested requirements	Basics of Underground Mining, Mine Planning

19. Objectives	This course develops the knowledge and skills in the field mine closure as an

	interdisciplinary area in the field of mining engineering. Due to complexity, the lectures covers the environment of decision making during the process and addresses the influencing factors, groups of relevant actors and challenges. The module aims to educate students about design of mine closure plans in different situations and shows the technical, environmental, social and legal aspects. Furthermore, the communication of concepts is emphasized during the course. Hence, the students should be able after completion of the course to plan the basic steps of a mine closure process and identify influencing factors and social groups. Furthermore, the students are able to assess the relative risks for the whole process of the single factors. To communicate effectively, the students are able to perform a stakeholder assessment and suggest communication strategies based on the results.
20. Media	Moodle and Video based Pre-Course and support during course Workshop with oral presentation and discussion (supported by analog and digital media)
21. Literature	• Australian and New Zealand Minerals and Energy Council: Strategic framework for mine closure. Australia : Australian and New Zealand Minerals and Energy Council, 2000 • Heikkinen, P. M. (Hrsg.); Noras, P. (Hrsg.); Salminen, R. (Hrsg.): Mine closure handbook : Environmental techniques for the extractive industries. Vammalan Kirjapaino Oy, Finland : Geological Society of Finland, 2008 • Jessup Bingham, Evelyn Louise: Closure Planning. Chapter 16.7. In: Darling, Peter (Hrsg.): SME mining engineering handbook. 3. ed. Englewood, Col. : SME - Soc. for Mining Metallurgy and Exploration, 2011, S. 1753–1764 • Lacy, H.: Closure and Rehabilitation of Gold Mines with a Focus on Tailings Storage Facilities. In: Adams, Mike D. (Hrsg.): Gold ore processing : Project development and operations. 2nd edition. Amsterdam, Boston, Heidelberg : Elsevier, 2016, S. 241–253 • Nichols, Brandon ; Veiga, Marcello ; van Zyl, Dirk ; Xavier, Andre Moura: Closure of Artisanal Small Scale Gold Mining Processing Plants in Ecuador. In: Journal of Management and Sustainability 5 (2015), Nr. 2 • Further literature will be announced
22. Other	-

Assessment					
23. No.	24. Respective Lecture	25. Type	26. LP	27. Grading	28. Emphasis
1	Report on Mine Closure	PV	3	graded	50%
2	Oral exam on Mine Closure	MP		graded	50%

On No. 1: Report on Mine Closure	
29a. Type of Assessment	Report on a new case study, • Identification of relevant parameters for the project • Development and justification of a concept • Assessment of the concept (strengths/ weaknesses)
30a. Examiner	S. Nowosad, M.Sc.
31a. Compulsory Prerequisite for Exam	-

On No. 2: Oral exam on Mine Closure	
29b. Type of Assessment	Oral examination on • Communication: Present concept to one defined stakeholder • Q/A session regarding concept
30b. Examiner	S. Nowosad, M.Sc.
31b. Compulsory Prerequisite for Exam	Report on Mine Closure

1. Title of Module
Selected Chapters of Underground Emergency Response

2. Integrated in following Study programs			
M.Sc. Mining Engineering			
3. Responsible Person for the module Hon.-Prof. Dr.-Ing. Walter Hermülheim		4. Responsible Faculty for the module Faculty of Energy and Economic Sciences	5. Number of the Module 16.10
6. Language English	7. LP 3	8. Duration [X] 1 Semester [ ] 2 Semester	9. Offering [ ] every semester [X] every year [ ] inconstant
10. Learning objectives / Skills See below			

Courses						
11. No.	12. Course title	13. Lecturer	14. Course No.	15. Course type	16. SWS	17. Workload Contact hours- / Self-Study time
1	Selected Chapters of Underground Emergency Response	Hon.-Prof. Dr.-Ing. Walter Hermülheim	W 6897	2V	2	28 h / 62 h
				Sum:	2	28 h / 62 h

On No. 1: Basics of Fire Protection and Mine Rescue	
18. Suggested requirements	Underground work experience (internship); Previous completion of lectures Fundamentals of Underground Mining, Mine Ventilation, Underground Mine Safety

19. Learning Objectives./ Skills	Develop an understanding for necessities, logical relations and methods concerning the prevention and control of catastrophic accidents in mining. Enable a production engineer To plan, implement, supervise and monitor preventive and active measures against fires, explosions, harmful gases and other underground hazards; To act properly in the first hour of an unexpected mine emergency, regarding the safe evacuation of the workforce and the deployment of the mine rescue brigade.
20. Media	Presentations, tuition talks, group exercises; Textbooks as download from the TUC-publication-server: https://doi.org/10.21268/20230118-0 and https://doi.org/10.21268/20230227-0
21. Literature	Hermülheim, W. et al.: Handbuch für das Grubenrettungswesen im Steinkohlenbergbau (Colliery Mine Rescue Handbook, in German). VGE-Verlag, 2007. Michelis, J.: Explosionsschutz im Bergbau unter Tage. Verlag Glückauf, 1998. Mitchell, D.: Mine Fires – Prevention, Detection, Fighting. 3. Ed. Intertech Publishing, 1996. Ramlu, M. A.: Mine Disasters and Mine Rescue. Orient Blackswan Pvt. Ltd., 2018. Strang, J./ MacKenzie-Wood, P.: A Manual on Mines Rescue, Safety and Gas Detection. Austcue Publishers, 1985. Hein, N./ Hermülheim, W./ Fuchs, E./ Culmann, J. et al.: Beurteilung der Analysenergebnisse von Grubenbrandgasproben (Mine Fire Gas Analysis, in German). Pirrot, 1995. Hermülheim, W.: Organization and Training of Volunteer Mine Rescue Brigades. 29. Int. Conf. of Safety in Mines Research Institutes, Beijing, 2007, 389/97. Martens, P. N./ Hermülheim, W.: Disaster Prevention in Deep Hard Coal Mining – A German Review. SME Annual Meeting, Phoenix, AZ, 2010, 308/313. Hermülheim, W.: Zen and the Art of Mine Rescue. 6. Int. Symposium on High Performance Mining, RWTH Aachen University, 2014, 385/398. Reprint in: Mining Report Glückauf 150 (2014), 265/276. Hermülheim, W.: Safe Control of Spontaneous Combustion Goaf Fires. 7. Int. Mine Rescue Conference, Hanover, 2015. https://minerescue.org/wp-content/uploads/2019/01/2_09_hermuelheim.pdf. Hermülheim, W./ Kuhn, M.: Adjusting Mine Rescue to the Requirements of Small Mining Enterprises. 7. Int. Mine Rescue Conference, Hanover,

	2015. www.minerescue.org/wp-content/uploads/2019/01/2_06_kuhn.pdf. Hermülheim, W: A Situational Analysis of open Questions in current Mine Rescue Practice. GeoResources Journal 03/2016, 45/50. www.georesources.net/download/GeoResources-Journal-3-2016.pdf. Hermülheim, W.: Hazard Analysis on Underground Mine Fires in Collieries. Zur Gefährdungsanalyse bei Grubenbränden im Kohlebergbau. Mining Report 152 (2016), 424/433. https://mining-report.de/wp-content/uploads/2016/10/MiRe_1605_Hazard_Analysis_160923.pdf Hermülheim, W.: Zur Anwendung von Grubenwehr-Klimatabellen (Mine Rescue Climate Tables, in German). Tagung der Berufsgenossenschaft Rohstoffe und chemische Industrie (BG RCI) für Oberführerinnen und Oberführer von Grubenwehren in Essen, 07. – 08. November 2018. Brendenahl, C./ Dippe, H./ Hermülheim, W./ Petrasch, H., Preißler, R.: Das neue Rettungswerkeverzeichnis des Deutschen Ausschusses für das Grubenrettungswesen. Directory of Mine Rescue Works Updated by the German Committee for Mine Rescue Services. Mining Report Glückauf 157 (2021), 153/163. Hermülheim, W.: Das Grubenrettungswesen in Deutschland nach dem Ende des Steinkohlebergbaus. Mine Rescue Services in Germany after the End of Hard Coal Mining. Mining Report Glückauf 158 (2022), 14/30. Hermülheim, W. (2023): The Mine Manager's Guide to Underground Emergency Response. TUC-Lectures on Mine Rescue, Fire and Explosion Protection. Clausthal University of Technology (TUC). https://doi.org/10.21268/20230118-0. Hermülheim, W. (2023): The Mine Manager's Guide to Underground Mine Safety. TUC Lectures on Occupational Safety and Health and on Basics of Emergency Response. Clausthal University of Technology (TUC). https://doi.org/10.21268/20230227-0. Additional selected literature on emergency control, e. g. regulations, conference papers, and mine rescue handbooks/ training materials available online: esb.bezreg-arnsberg.nrw.de https://miningquiz.com https://www.bgrci.de/notfallmanagement https://www.cdc.gov/niosh/mining/ https://www.coalservices.com.au/mining/mines-rescue/ https://deutsche-grubenrettung.de/ https://www.hauptstelle.at/ https://www.hse.gov.uk/mining/ https://minerescue.org/

	https://minesrescue.co.za https://www.msha.gov/ https://www.qmihsconference.org.au/ https://qmrs.com.au/Resources.html https://www.workplacesafetynorth.ca/industries/mining
22. Other	Course Outline: Fire prevention and detection, fire fighting equipment, manual fire fighting, fires and ventilation, sealing off fires, fire fighting with inert gases Gas testing and gas analysis, Graham's Ratio and Coward-Diagrams, control of explosion prone fires Noxious gases underground, gas detection, breathing protection Organization, equipment and training of mine rescue brigades, emergency and operational mine rescue work Communication and stress during mine rescue operations, public relations and press work, decision making during emergencies Underground self rescue and escape, rescue of entrapped persons Explosion protection and explosive dust control in collieries Group exercises: mine fire scenarios; operational mine rescue work; decision making in incident control teams; measures during the first hour of a mine emergency Block course (4 days): Excursion to Hauptstelle für das Grubenrettungswesen (Clausthal Mine Rescue Center), Berufsgenossenschaft Rohstoffe und Chemische Industrie, BG RCI, Berliner Straße 2, 38678 Clausthal-Zellerfeld (4 hours), if available during the lecture week

Assessment

23. No.	24. Respective Lecture	25. Type	26. LP	27. Grading	28. Emphasis
1	Selected Chapters of Underground Emergency Response	MP	3	graded	100 %

On No. 1: Basics of Fire Protection and Mine Rescue

29. Type of Assessment	Written examination (120 min).
30. Examiner	Hon.-Prof. Dr.-Ing. Walter Hermülheim
31. Compulsory Prerequisite for Exam	-

1. Title of Module

Mining Technology and Automation

2. Integrated in following Study programs

M.Sc. Mining Engineering

3. Responsible Person for the module		4. Responsible Faculty for the module	5. Number of the Module
S. Nowosad, M.Sc.		Faculty of Energy and Economic Sciences	16.11
6. Language	**7. LP**	**8. Duration**	**9. Offering**
English	3	[X] 1 Semester [ ] 2 Semester	[ ] every semester [X] every year [ ] inconstant

10. Learning objectives / Skills

After taking the lecture, the student has deep knowledge on

- Mining technology and automation including equipment development and mechanization in underground mines
- Contemporary technological trends in mining
- Advantages of the implementation of new technologies
- Safety concerns related to the implementation of new technologies
- Restrictions and challenges for the implementation of new technologies
- Technological and autonomous global market overview
- System implementation, digital transformation and the foundational technologies necessary for the adoption of contemporary technologies

and is able to

- Identify the drivers of technological change
- understand the factors that impact the implementation of new technologies in mining operations and/or greenfield projects
- identify the safety challenges of a technological implementation by assessing it in case studies
- understand the benefits, value drivers and effects of technological changes on current processes
- analyze and assess a technological implementation by identifying related KPIs
- understand the most important properties, key values, opportunities and overall challenges of technological change in mining operations and/or greenfield projects

Courses

11. No.	12. Course title	13. Lecturer	14. Course No.	15. Course type	16. SWS	17. Workload Contact hours- / Self-Study time
1	Mining Technology and Automation	S. Nowosad, M.Sc.	W6888	V	2	28 h / 62 h
				Sum:	2	28 h / 62 h

On No. 1: Mining Technology and Automation	
18. Suggested requirements	-
19. Objectives	After taking the lecture, the student has deep knowledge on has deep knowledge on ♦ Mining technology and automation including equipment development and mechanization in underground mines ♦ Contemporary technological trends in mining ♦ Advantages of the implementation of new technologies ♦ Safety concerns related to the implementation of new technologies ♦ Restrictions and challenges for the implementation of new technologies ♦ System implementation, digital transformation and the foundational technologies necessary for the adoption of contemporary technologies and is able to ♦ Identify the drivers of technological change ♦ understand the factors that impact the implementation of new technologies in mining operations and/or greenfield projects ♦ identify the safety challenges of a technological implementation by assessing it in case studies ♦ understand the benefits, value drivers and effects of technological changes on current processes ♦ analyze and assess a technological implementation by identifying related KPIs ♦ understand the most important properties, key values, opportunities and overall challenges of technological change in mining operations and greenfield projects
20. Media	Projector-based presentation, group work and hands-on project
21. Literature	♦ Barsotti, C., and Kitchener L.C. 1981. The development of "in the hole" drilling and remote-control equipment at INCO Metals Company. In Design and Operation of Caving and Sublevel Stopping Mines. Edited by D.R. Stewart. Littleton, CO: SME-AIME. Pp. 643-652 ♦ Camm, T.W., and Stebbins, S.A. 2020. Simplified Cost Models for Underground Mine Evaluation: A. Handbook for Quick Prefeasibility Cost Estimates. Butte: Mining Engineering Department, Montana Technological University. ♦ CISCO. 2020. Industrial Automation in Mining Environments: Design Guide, Release 1.5. www.cisco.com. Accessed July 2023. ♦ CISCO. 2020. Wireless Networks Enabling Autonomous Vehicles for Underground Mines, Release 1.5. www.cisco.com. Accessed June 2023. ♦ Darling, P., ed. 2023. SME Underground Mining Handbook, 2nd ed. Littleton, CO: SME: 607-633 ♦ Darling, P., ed. 2011. SME Mining Engineering Handbook, 3rd ed. Littleton, CO: SME. ♦ GMG (Global Mining Guidelines Group). 2019. Guideline for the Implementation of Autonomous Systems in Mining. https://gmggroup.org. Accessed September 2023 ♦ GMG (Global Mining Guidelines Group). 2022. Recommended Practices for Battery Electric Vehicles in Underground Mining, version 3. https://gmggroup.org. Accessed September 2023 ♦ Groover, M. 2015. Automation, Production Systems, and Computer-Integrated Manufacturing, 4th ed. New York: Pearson.

	♦ ISO/IEC 22989:2022 (en). Information Technology-Artificial Intelligence concepts and Terminology. www.iso.org. Accessed July 2023. ♦ Olavarria, S., Adriasola P., and Karzulovic A. 2006. Transition from open pit to underground mining at Chuquicamata, Antofagasta, Chile. In the South African Institute of Mining and Metallurgy, International Symposium on Stability of Rock Slopes in Open Pit Mining and Civil Engineering, Johannesburg: South African Institute of Mining and Metallurgy. Pp. 421-434 ♦ Radziwill, N.M. 2020. Connected, Intelligen, Automated: The Definitive Guide to Digital Transformation and Quality 4.0. Milwaukee, WI: Quality Press ♦ SAE International. 2021 SAE J3016 taxonomy and definition for terms related to driving automation systems for on-road motor vehicles. April 30. https://saemobilus.sae.org. Accessed July 2023. ♦ Sifferlinger, N.A. 2021. The limits of mechanical excavation and jacking in mining 2020. In the 22nd Colloquium, Drill and Blasting Technology. Clausthal-Zellerfeld: Institute of Mining, Clausthal University of Technology. ♦ Vogt, D. 2016. A review of rock cutting for underground mining: Past, present and future. Journal of the southern African Institute of Mining and Metallurgy 116(11): 1011-1026 ♦ Further literature will be announced during the lecture
22. Other	

Assessment					
23. No.	24. Respective Lecture	25. Type	26. LP	27. Grading	28. Emphasis
1	Mining Technology and Automation	MP	3	graded	100%

On No. 1: Mining Technology and Automation	
29. Type of Assessment	Oral examination (30 – 40 min) or Written examination (90 min), will be announced at start of the semester
30. Examiner	S. Nowosad, M.Sc.
31. Compulsory Prerequisite for Exam	Participation in the “Case Study presentation” part of session 6, specific dates for session 6 will be announced at start of the semester