TU Clausthal

Modulhandbuch

Master of Science

"Mining Engineering"

Fakultät für Energie- und Wirtschaftswissenschaften
der Technischen Universität Clausthal

26. Mai 2015

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List of abbreviations:

General:

hpw	Hours per week (Work load)
CP	Credit Point (1CP entspricht 1 ECTS-Punkt)

Course type / Modul:

(PF)	Compulsory subject
(WPF)	Compulsory optional subject
(WF)	Elective (additional Exam)

Type of Modul:

V	Lecture
Ü	Exercise
V/Ü	Lecture and exercise
V/E	Lecture and fieldtrip
P	Project report
St.	Student research project
S	Seminar paper
AB	Written rhesis
B	Written report

Type of Exam:

(K)	Written Exam
(M)	Oral Exam
(H)	Thesis/paper
(R)	Presentation
(P)	Internship

Skills:

FK	Professional skills
MK	Technical skills
SK	System expertise
SOK	Social skills

Module 1 Shaft Sinking

Degree Programme:	M.Sc. Mining Engineering
Number of the Module	1
Name of the Module:	Shaft Sinking
Coruse(s):	Shaft Sinking and Deep Foundations Tutorial for Shaft Sinking and Deep Foundations
Term:	1
Responsible person for the module:	Univ.-Prof. Dr.-Ing. Oliver Langefeld
Lecturer:	Univ.-Prof. Dr.-Ing. Oliver Langefeld
Language:	English
Position within the Curriculum:	Compulsory subject (PF)

Course Type	SPW	Work Load [h] Contact hours-/ Independant Studies	ECTS	Skills FK	MK	SK	SOK
Lecture and Tutorial Shaft Sinking and Deep Foundations (2V+2Ü)	4	56/124	6	50	30	10	10

Requirements:	-
Learning objectives / Skills:	The student to use appropriate knowledge, principles and techniques to plan and execute the sinking and construction of pre-shafts, shafts, staples and inside shafts, ventilation boreholes and auxiliary shafts in underground mines. To plan and execute the construction of pillars in deep foundations, vertical sub-surface technical barriers and dams, subterraneous curtains and bored pile walls, construction pits and construction shafts both in structural engineering and in civil engineering projects in transportation and infrastructure like harbours, bridges, dams, utility supplies, channels and tunnels. The student to identify, analyse and solve engineering problems resulting from the need to conduct shaft sinking and deep foundations in mining as well as in civil engineering projects, and to enable the students to apply this knowledge in order to develop, discuss and justify proper engineering solutions to those tasks and problems
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)
Assessment:	Assignment (homework, exercise, presentation) (25%) and Oral (30 – 40 min) or Written (90 min) examination (75%)
Media:	Lecture (Activity-based Learning Approach), Beamer-Presentation, Skript, Tutorials, Laboratory, Group and Project works
Literature:	• SME Mining Engineering Handbook • Surface and Underground Excavations • Secondary literature-to be announced in the lecture
Additional Information:	The Tutorial is held in a block course within three days. The date is announced at the beginning of the semester

Module 2 International Mining

Degree Programme:	M.Sc. Mining Engineering
Number of the Module:	2
Name of the Module:	International Mining
Course(s):	International Mining Seminar for International Mining Mining and Finance Tutorial for Mining and Finance
Term:	1
Responsible person for the module:	Univ.-Prof. Dr.-Ing. habil. Tudeshki
Lecturer:	Univ.-Prof. Dr.-Ing. habil. Tudeshki
Language:	English
Position within the Curriculum:	Compulsory Subject (PF)

Course Type	**hpw**	**Work Load [h] Contact hours-/Self-Study time**	**CP**	**Skills**			
				FK	**MK**	**SK**	**SOK**
International Mining	1	14/46	2	5	30	50	15
Seminar for International Mining	1	14/16	1	15	30	30	25
Mining and Finance	1	14/46	2	5	30	50	15
Tutorial for Mining and Finance	1	14/16	1	5	45	50	0

Requirements:	-
Learning objectives / Skills:	International Mining: 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, which is combined to the project work of Mining and Finance, the students will work on a special topic of international mining and train the capabilities of free speech. Mining and Finance: 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.
Course Outline:	International Mining: • 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 Mining and Finance: • 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:	group work with final presentation (seminar)
Media:	lecture, projector-presentation, lecture notes

	PC-based spreadsheet analysis
Literature:	announcement in the lecture
Additional Information:	-

Module 3 Geoinformation Systems (GIS)

Degree Programme:	M.Sc. Mining Engineering
Number of the Module:	3
Name of the Module:	Geoinformation Systems (GIS)
Course(s):	Geoinformation Systems Tutorial for Geoinformation Systems GIS-based analysis and surface modelling
Term:	1 and 2
Responsible person for the module:	Prof. Busch
Lecturer:	Prof. Busch
Language:	English
Position within the Curriculum	Compulsory subject (PF)

Course Type	**hpw**	**Work Load [h] Contact hours-/ Self-Study time**	**CP**	**Skills**			
				FK	**MK**	**SK**	**SOK**
Geoinformation Systems	2	28/24	6	40	40	10	10
Tutorial for Geo-information Systems	1	14/24		10	30	30	30
GIS-based analysis and surface modelling	2	28/62		30	30	20	20
Total:	5	70/110	6	30	34	18	18

Requirements:	-
Learning objectives / Skills:	Profound understanding about theoretical aspects of modeling of spatial objects, knowledge about principles of Geographic Information Systems and their functionalities; Ability to use the software ArcGIS (ESRI) and to use special functions for spatial analysis and modeling of surfaces.
Course Outline:	Introduction to GIS, definitions, purpose of GIS, Geographic Information and Spatial Data, GIS-functionality, thematic mapping; Computer-lab courses: basic functionalities of ArcGIS software and advanced geo-data processing with ArcGIS, Digital Elevation Models, spatial interpolation methods, proximity analysis, overlay functions, design of thematic maps
Assessment:	Written examination (180 min)
Media:	lecture, beamer presentation, lecture notes, computer-lab-course
Literature:	• Graeme F. Bonham-Carter: Geographic Information Systems for Geoscientists: Modelling with GIS. • Nicholas Chrisman: Exploring geographic information systems. • de Buy et al.: Principles of Geographic Information Systems. • Tor Bernhardsen: Geographical Information Systems. • David J. Unwin, David O'Sullivan: Geographic Information Analysis • Michael N. DeMers: Fundamentals of Geographic Information Systems. • Laurie Kelly, Michael F. Worboys, Matt Duckham. GIS. A computing perspective. • Robert Laurini, Derek Thompson: Fundamentals of spatial information systems. • David J. Maguire, Michael F. Goodchild, David W. Rhind: Geographical Information Systems. • ArcGIS online manual and resource centre (http://resources.arcgis.com/en/help/main/10.1/).
Additional Information:	-

Module 4 Mineral Resources

Degree Programme:	M.Sc. Mining Engineering
Number of the Module:	4
Name of the Module:	Mineral Resources
Course(s):	Geostatistics Economic Geology
Term:	1 and 2
Responsible Person for the Module:	Prof. Lehmann
Lecturer:	Prof. Lehmann Dr. Müller
Language:	English
Position within the Curriculum:	Compulsory subject (PF)

Course Type	hpw	Work Load [h] Contact hours-/Self-Study time	CP	Skills FK	MK	SK	SOK
Geostatistics	2	28/62	3	20	40	40	0
Economic Geology	2	28/62	3	20	40	30	10

Requirements:	-
Learning Objectives / Skills:	Geostatistics The students will learn to understand the principles and calculation methods of geostatistical models and their applications (e.g. kriging) in modern simulation methods. Economic Geology Basic knowledge of geology related to mineral deposits, and understanding ore deposits in the framework of Earth evolution.
Course Outline:	Geostatistics • 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) Economic Geology Structure of the Earth, geologic time, global geological cycles, rocks and ore, water, magmatic and hydrothermal ore deposits, weathering
Assessment:	Oral (30 min) or written examination (60 min)
Media:	Lecture, projector-presentation, lecture notes
Literature:	Geostatistics: 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 p. Olea RA (1999) Geostatistics for engineers and Earth scientists. Kluwer, 303 p, Economic Geology: Pohl WL (2013) Economic geology: principles and practice. Wiley-Blackwell, 680 p.
Additional Information:	Recommended: 1-day field trip (Geology of the Harz Mountains)

Module 5 Advanced Drilling Engineering I

Degree Programme:	M.Sc. Mining Engineering
Number of the Module	5
Name of the Module	Advanced Drilling Engineering I
Lehrveranstaltungen:	Advanced Drilling Engineering I Tutorial for Advanced Drilling Engineering I
Semester:	1
Responsible person for the Module:	PD Dr. Dr-Ing. habil. Catalin Teodoriu
Lecturer:	PD Dr. Dr-Ing. habil. Catalin Teodoriu
Language:	English
Position within the Curriculum:	Compulsory Subject (PF)

Course Type	**hpw**	**Work Load [h] Contact hours-/ Self-Study time**	**CP**	**Skills**			
				FK	**MK**	**SK**	**SOK**
Advanced Drilling Engineering (2V + 1Ü)	3	42/48	3	50	20	20	10

Requirements:	-
Learning objectives / Skills:	Specialized knowledge of drilling technology, including machines and special application Advanced Applications in the Drilling Practice Provides students with an introduction to advanced drilling topics such as underbalanced drilling, modern drilling technologies, geothermal well drilling and fishing operations. Additionally this course offers the opportunity to learn about team work.
Course Outline:	Drilling Concepts (Drilling the Limit, etc.) Well Design Procedure (Well Construction) Drilling Optimization Drilling Performance Analysis Drillstring Dynamics Drilling Problems (Risk Analysis, Solutions) HP/HT Wells, Horizontal and Extended Reach Wells, Multilaterals Under Balanced Drilling New Developments in Drilling Operations Offshore Drilling (Well Design and Special Consideration) Blow Out (Fire Fighting) Geothermal Drilling Technology Drilling through Gas Hydrates Case Studies
Assessment:	Written Examination (90 min)
Media:	Interactive multimedia presentation, Video, Skript, Präsenzübung, Hands-On Teaching
Literature:	SPE.ORG the eLibrary of SPE
Additional Information:	The Turorial will be „Hands-on teching“. The concept connects the theoretical topics of the lecture with practical aspects and experiments. The main goal of this approach is to handover small projects to the students, in order for them to get a better understanding of the theoretic topics of the lecture. The small projects can be the development of functioning models.

Module 6 Advanced Mine Ventilation and Climatization

Degree Programme:	M.Sc. Mining Engineering
Number of the Module	6
Name of the Module:	Advanced Mine Ventilation and Climatization
Coruse(s):	Advanced Mine Ventilation and Climatization Tutorial Advanced Mine Ventilation and Climatization
Term:	2
Responsible person for the module:	Univ.-Prof. Dr.-Ing. Oliver Langefeld
Lecturer:	Univ.-Prof. Dr.-Ing. Oliver Langefeld
Language:	English
Position within the Curriculum:	Compulsory Subject (PF)

Course Type	SPW	Work Load [h] Contact hours-/ Independant Studies	ECTS	Skills			
				FK	MK	SK	SOK
Advanced Ventilation and Climatization (2V + 2Ü)	4	56/124	6	50	30	10	10

Requirements:	-
Learning objectives / Skills:	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, minimise and/or manage these hazards • Identify, analyse and solve engineering problems regarding gas and dust occurences • Identify, analyse 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
Course Outline:	• Review of mine ventilation Basics • Ventilation Network Analysis and surveys • Planning and optimisation of mine ventilation systems • Dust and Gas emissions control in mines • Design and Planning of Mine refrigeration systems • Mine Ventilation Project
Assessment:	Assignment (20%) and oral (30 min) or written examination (90 min) (80%)
Media:	Lecture (Activity-based Learning Approach), Beamer-Presentation, Skript, Tutorials, Group and Project works. The Tutorial/ Exercise will be conducted in the ventilation laboratory as well as in the teaching mine “Rammelsberg”.

Literature:	• 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.
Additional Information:	-

Module 7 Underground Mining Equipment

Degree Programme:	M.Sc. Mining Engineering
Number of the Module:	7
Name of the Module	Underground Mining Equipment
Course(s):	Mining Machinery & Equipment Excavation Machines
Term:	2 and 3
Responsible person for the module:	Univ.-Prof. Dr.-Ing. Oliver Langefeld
Lecturer:	Univ.-Prof. Dr.-Ing. Oliver Langefeld
Language:	English
Position within the Curriculum:	Compulsory Subject (PF)

Course Type	**hpw**	**Work Load [h] Contact hours –/ Self-Study time**	**CP**	**Skills**			
				FK	**MK**	**SK**	**SOK**
Mining Machinery & Equipment (V)	2	28/62	3	40	20	20	20
Excavation Machines(V)	2	28/62	3	40	20	20	20

Requirements:	-
Learning objectives / Skills:	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 Deciding which kind and size of machinery is the right for a special application
Course outline:	Mining Machinery a. Longwall Mining Equipment b. Longwall Variations with special equipment c. Maintenance d. Jumbo Drill e. Production Drill f. Mine Support Excavation Machines g. Road Heading Machines h. Tunnel Boring Machines i. Continuous Miner j. Load-Haul-Dump k. Trucks l. Infrastructure m. Crusher n. Water Management
Assessment:	Assignment (homework, exercise or presentation) (25%) and Oral (30 – 40 min) or Written (90 min) examination (75%)
Media:	Oral presentation with Power Point, Exercises and discussions
Literature	• SME Mining Handbock • Equipment Management • Mining Engineering Analysis • Longwall Mining, Peng • Strata Control in in-seam roadways, Junker
Additional Information:	-

Module 8 Advanced Rock Mechanics

Degree Programme:	M.Sc. Mining Engineering
Number of the Module:	8
Name of the Module:	Advanced Rock Mechanics
Course(s):	Advanced Rock Mechanics
Term:	2
Responsible person for the module:	apl. Prof. Dr.-Ing. habil. Uwe Düsterloh
Lecturer:	apl. Prof. Dr.-Ing. habil. Uwe Düsterloh
Language:	English
Postition within the Curriculum:	Compulsory Subject (PF)

Course Type	**hpw**	**Work Load [h] Contact hours-/ Self-Study time**	**CP**	**Skills**			
				FK	**MK**	**SK**	**SOK**
Advanced Rock Mechanics (2L + 2T)	4	56/124	6	50	30	10	10

Requirements:	-
Learning objectives / Skills:	Based on the lecture students are able to handle the basics of a geotechnical safety assessment for underground excavations. Students can determine geotechnical parameters for rock mass as well as parameters regarding constitutive models based on lab tests. They have the capabillity to compute the state of stress and strain in the rock mass surrounding underground excavations by using analytical solutions. Finally students can read, verify, validate and evaluate results given from numerical calculations to estimate static stability and thightness of underground structures.
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:	Written Examination (120 min)
Media:	Lecture, beamer presentation, lecture notes, exercises, experimental equipment
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, Mai 2000, Hague.
	/18/	Düsterloh,U.; Lux, K.-H. (2012): Impact of lab tests on rock salt for an economical optimization of salt caverns, Mechanical Behaviour of Salt VII, Balkema, Taylor & Francis Group, London UK, pp 343-352, ISBN 978-0-415-62122-9.
	/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 CO_2 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.
	/28/	Brady, B.H.G.; Brown, E.T. (1985): Rock mechanics for underground mining, George, Allen & Unwin, London.
	/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.

Additional Information:	-

Module 9 Advanced Mine Surveying

Degree Programme:	M.Sc. Mining Engineering
Number of the Module:	9
Name of the Module:	Advanced Mine Surveying
Course(s):	Basics of Strata and Ground Movements Mine Mapping Remote Sensing Tutorial for Remote Sensing
Term:	2 and 3
Responsible person for the module:	Prof. Busch
Lecturers:	Prof. Busch
Language:	English
Position within the Curriculum:	Compulsory Subject (PF)

Course Type	**hpw**	**Work Load [h] Contact hours-/ Self-Study Time**	**CP**	**Skills**			
				FK	**MK**	**SK**	**SOK**
Strata and Ground Movements (V)	1	14/40	6	40	40	10	10
Mine Plans (V)	1	14/22		40	40	10	10
Applied Remote Sensing (V)	1	14/22		40	40	10	10
Tutorial for Applied Remote Sensing (Ü)	1	14/40		20	20	40	20
Total:	4	56/124	6	35	35	18	12

Requirements:	-
Learning objectives / Skills:	Students will understand geomechanical processes, from the development of an underground mining cavity up to the deformation of the ground surface: incl. possibilities for the detection of ground movements, classification of ground movements and methods to reduce impacts. Students acquire knowledge about the basics of mine mapping: authorization, preparation and composition of mine-plans in international comparison. Students learn abilities for documentation and visualization of mining activities. Students will understand physical basics of remote sensing and learn methods and software tools for applications related to mining activities, e.g. mineral exploration, mapping of environmental impacts, monitoring of ground movements and hazards.
Course Outline:	• Introduction to the topics rock and ground movements • Methods for detection of ground movements and ground and object deformation • prediction of ground movements • subsidence from abandoned mines • Risk assessment of suspected areas, measures to reduce mining damage • Legal regulation of mining subsidence • cartographic design and illustrations • Importance and international legal regulations of mine mapping • map projections, sections and perspective imaging • components of mine plans, national standards • preparation & layout and construction in mine plans • Principles of satellite remote sensing • Satellite & sensors: properties, search and ordering of data • Digital Image processing with ENVI/IDL software • Image enhancement, correction, classification and transformation • Introduction to hyperspectral remote sensing for mineral exploration • Lithological mapping using ASTER images • Introduction and application of SAR for mapping of mining induced ground

	movements; NEST SAR processing
Assessment:	Written Examination (180 min)
Media:	lecture, beamer presentation, lecture notes, computer-lab-course
Literature:	Kratzsch, H.: Mining Subsidence Engineering, Springer-Verlag, 1983. Empfehlung „Geotechnisch-markscheiderische Untersuchung und Bewertung von Altbergbau“. In: Proceedings zum 4. Altbergbau-Kolloquium, 4.-6.11.2004, Leoben. Glückauf-Verlag, 2004. Williams, W. R.: Mine Mapping and Layout. Prentice-Hall Inc., New Jersey 1983. Schulte, G., Löhr, W., Vosen, H.: Markscheidekunde. Springer-Verlag, Berlin 1969. National Mining Standards and Regulations, e.g. Markscheider Bergverordnung 1986 (Germany), Surveying practice and statutory plans; NCB ; 1955 (England); Code of Federal Regulations, Mineral Resources (U.S. Government). Lillesand, Th.M., Kiefer, R.W.: Remote Sensing and Image Interpretation. 6 . Aufl., John Wiley and Sons Ltd., London, 2008. Rees, W.G.: Physical Principles of Remote Sensing. 3. Aufl., Cambridge University Press, 2012. Richards, J.A., Jia, X.: Remote Sensing Digital Image Analysis: An Introduction. Springer-Verlag Berlin und Heidelberg, 2006. Hanssen, R.: Radar Interferometry – Data Interpretation and Error Analysis. Kluwer Academic Publishers, 2001.
Additional Information:	-

Module 10 Mineral Processing

Degree Programme:	M.Sc. Mining Engineering
Number of the Module:	10
Name of the Module:	Mineral Processing
Course(s):	Mineral Processing
Term:	2
Responsible person for the module:	Prof. A. Weber
Lecturers:	Prof. A. Weber
Language:	English
Position within the Curriculum:	Compulsory Subject (PF)

Course Type	**hpw**	**Work Load [h] Contact hours-/ Independant hours**	**CP**	**Skills FK**	**MK**	**SK**	**SOK**
Mineral Processing Lecture and Tutorial 2V / 1Ü	3	42 /48	3	50	20	20	10

Requirements:	-
Learning objectives / Skills:	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 on plant practice will be integrated.
Course Outline:	• Introduction • Fundamentals • Size reduction • Sizing separation • Concentration separation • Materials handling • Plant practice
Assessment:	Written Examination (90 min)
Media:	Lectures, beamer presentations, script, exercises in class
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)
Additional Information:	-

Module 11 Underground Mine Planning

Degree Programme:	M.Sc. Mining Engineering
Number of the Module	11
Name of the Module:	Underground Mine Planning
Coruse(s):	Underground Mine Planning Tutorial for Underground Mine Planning
Term:	2/3
Responsible person for the module:	Univ.-Prof. Dr.-Ing. Oliver Langefeld
Lecturer:	Dr.-Ing. Franz Xaver Spachtholz
Language:	English
Position within the Curriculum:	Compulsory Subject (PF)

Course Type	hpw	Work Load [h] Contact hours-/ Self-Study time	CP	Skills FK	MK	SK	SOK
Underground Mine Planning (2V)	2	28/62	3	50	30	10	10
Tutorial for Underground Mine Planning (Ü)	2	28/62	3	30	30	20	20

Requirements:	Mining Basics, Economical Basics
Learning objectives / Skills:	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: 1. Identify, analyse 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. 2. Demonstrate practical skill necessary to undertake an underground mine planning survey together with necessary documentation, analysis and interpretation of results; a. Understand market needs and raw material politics (example to potash and salt) b. Compile technical, economic and other data required for mine planning; c. Understand reserve estimation methods d. Select a suitable mining method and related equipment for a given deposit; e. Plan and schedule mine development and production; run a draft pre-feasibility study (project work)
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
Assessment:	Marked Project (30%) and written examination (70%, 90 min)
Media:	Lecture (Activity-based Learning Approach), Beamer-Presentation, Skript, Tutorials, Group and Project works

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
Additional Information:	The Tutorial is held in a block course within two days. The date is announced at the beginning of the semester

Module 12 Advanced Surface Mining

Degree Programme:	M.Sc. Mining Engineering
Number of the Module:	12
Name of the Module:	Advanced Surface Mining
Course(s):	Advanced Surface Mining Mining and Environment
Term:	3
Responsible person for the module:	Univ.-Prof. Dr.-Ing. habil. Tudeshki
Lecturers:	Univ.-Prof. Dr.-Ing. habil. Tudeshki
Language:	English
Position within the Curriculum:	Compulsory Subject (PF)

Course Type	**hpw**	**Work Load [h]** **Contact hours-/ Independent hours**	**CP**	**Skills** **FK**	**MK**	**SK**	**SOK**
Advanced Surface Mining	2	28/62	3	30	30	30	10
Mining and Environment	2	28/62	3	25	25	25	25

Requirements:	-
Learning objectives / Skills:	Advanced Surface Mining: Students do learn special surface mining technologies. Aim of the course is to enable students to design open pit mines including the selection and dimensioning of mining equipment. Mining and Environment: Students will understand and critically consider the complex objectives, tasks and content of water management and reclamation, which are closely associated. After completion of the course they are enabled to interpret exploration study results and apply them to other projects.
Course Outline:	Advanced Surface Mining: • factors influencing the selection and dimensioning of mining equipment • availability and effectiveness of equipment • selection and dimensioning of loading equipment • selection and dimensioning of haulage equipment • software-based selection and dimensioning of surface mining equipment • drilling and blasting technology and dimensioning of blasting in open pits Mining and Environment:. • soil physics, soil and rock mechanics • hydrogeology and hydrology • water management of open pits • dewatering technologies • dimensioning of water wells • legal aspects of reclamation • reclamation goals and technologies
Assessments:	Oral or written Examination (max. 90 minutes)
Media:	lecture, projector-presentation, lecture notes mine planning software
Literature:	announcement in the lecture
Additional Information:	-

Module 13 Applied Rock Mechanics

Degree Programme:	M.Sc. Mining Engineering
Number of the Module:	13
Name of the Module:	Applied Rock Mechanics
Course(s):	Applied Rock Mechanics
Term:	3
Responsible person for the module:	apl. Prof. Dr.-Ing. habil. Uwe Düsterloh
Lecturers:	apl. Prof. Dr.-Ing. habil. Uwe Düsterloh
Language:	English
Position within the Curriculum:	Compulsory Subject (PF)

Course type	**hpw**	**Work Load [h] Contact hours-/ Self-Study time**	**CP**	**Skills**			
				FK	**MK**	**SK**	**SOK**
Applied Rock Mechanics (2V+ 2Ü)	4	56/124	6	50	30	10	10

Requirements:	-
Learning objectives /Skills:	Students are able to handle various design techniques used in different mining areas (rock mass classification, room and pillar design, analytical solutions, calculation of subsidence, slope stability, selected earth statical analysis)
Course Outline:	* rock mass classification (RQD, ARMR, TQI, ..) * room and pillar design, roof dimensioning * analytical solutions for shafts and drifts in elastic, plastic and viscous rock mass * calculation of subsidence * dimensioning Longwall mining * anchor * slope stability * settlement, slide stabillity, slice method
Assessment:	Written Examination (120 min)
Media:	Lecture, beamer presentation, lecture notes, exercises, experimental equipment
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).
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/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, Mai 2000, Hague.
/18/ Düsterloh,U.; Lux, K.-H. (2012): Impact of lab tests on rock salt for an economical optimization of salt caverns, Mechanical Behaviour of Salt VII, Balkema, Taylor & Francis Group, London UK, pp 343-352, ISBN 978-0-415-62122-9.
/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 CO_2 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.
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/29/ Herget, G. (1988): Stresses in rock, A.A. Balkema, Rotterdam, Brookfield.
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/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.

Additional Information:	-

Module 14 Seminar

Degree:	M.Sc. Mining Engineering
Number of the Module :	14
Name of the Module:	Seminar
Course(s):	Seminar
Term:	1
Responsible person für the module:	Univ.-Prof. Dr.-Ing. Oliver Langefeld
Lecturer:	Professors involved in the Masterprogram Mining Engineering
Language:	English
Position within the Curriculum:	Compulsory Subject (PF)

Course Type	**hpw**	**Work load [h] Contact hours-/ Self-Study time**	**CP**	**Skills**			
				FK	**MK**	**SK**	**SOK**
Seminar	2	28/62	3	25	25	25	25

Requirements:	-
Learning objectives / Skills:	The Goal of this Module 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 at improving the students 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.
Course outline:	Topics according to the lectures of the Master Mining Engineering
Assesment:	Written Thesis (max. 25 pages), oral presentation (about 20 minutes) and participation in the discussion following the presentation
Media:	Beamer presentation, Written Thesis, Handouts
Literature:	General Literature will be given by the supervisor when the Seminar begins
Additional Information:	-

Module 15 Industry Internship

Degree:	M.Sc. Mining Engineering
Number of the Module:	15
Name of the Module:	Industry Internship
Course(s):	Industry Internship
Term:	1
Responsible person for the module:	Univ.-Prof. Dr.-Ing. Oliver Langefeld
Lecturer:	-
Language:	English
Position within the Curriculum:	Compulsory Subject (PF)

Course Type	hpw	Work load [h] Contact hours-/ Self-Study time	CP	Skills FK	MK	SK	SOK
Industry Internship	1	14/166	6	20	10	30	40

Requirements:	-
Learning objectives/ Skills:	The Students get an insight into the practical work done in the industry. Additionally they get the possibility to enhance their social skills while working in teams and increase their experience presenting infront of groups.
Course Outline:	During the Internship the students learn to work on a topic with minimal supervision in a short amount of time. The topics worked on are part of the day to day work within the company, research Institution or government institution.
Assessement:	Written Report, and a presentation regarding the topics of the internship
Media:	Written Report, Presentation
Literature:	-
Additional Information:	The Industry Internship can be completed either within the industry, an research institution or a governmental institution.

Module 16 Student Research Project

Degree:	M.Sc. Mining Engineering
Number of the Module:	16
Name of the Module:	Student Research Project
Course(s):	Student Research Project
Term:	3 and 4
Responsible Person for the module :	Univ.-Prof. Dr.-Ing. Oliver Langefeld
Lecturer:	Professors involved in the Masterprogram Mining Engineering
Language:	English
Position within the Curriculum:	Compulsory Subject (PF)

Course Type	**hpw**	**Work load [h] Contact hours-/ Self-Study Time**	**CP**	**Skills**			
				FK	**MK**	**SK**	**SOK**
Student Research Project	3	42/138	6	20	10	30	40

Requirements:	-
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.
Course outline:	Topics according to the lectures of the Master Mining Engineering
Assessment:	Written Thesis (max. 20 pages per person) and a presentation of the (group) project
Media:	Written Thesis, Presentation
Literature:	General Literature will be given by the supervisor when the Student Research Project begins
Additional Information:	A student research project can be given by all professors involved in the curriculum. It is possible to do it at university or in industry.

Module 17 Master Thesis

Degree:	M.Sc. Mining Engineering
Number of the Module:	17
Name of the Module:	Master Thesis
Course(s):	Master Thesis
Term:	4
Responsible person for the module :	Univ.-Prof. Dr.-Ing. Oliver Langefeld
Lecturer:	Professors of the Institute of Mining
Language:	English
Position within the Curriculum:	Compulsory Subject (PF)

Course Type	**hpw**	**Work load [h] Contact hours-/ Independant studies**	**CP**	**Skills**			
				FK	**MK**	**SK**	**SOK**
Master Thesis	14	630	21	30	25	30	15

Requirements:	Admission according to § 11 Absatz 4 of the „Allgemeine Prüfungsordnung" (APO).
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 followup discussion with the audience.
Course outline:	Topics according to the lectures of the Master Mining Engineering
Assessement:	Written Thesis and an oral presentation of the results
Media:	Beamer, Written Thesis, oral presentation
Literature:	General Literature will be given by the supervisor when the Master Thesis begins
Additional Information:	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.

Module 18.1 Specialized Driving Methods

Degree Programm:	M.Sc. Mining Engineering
Number of the Module	18.1
Name of the Module:	Specialized Driving Methods
Course(s):	Specialized Driving Methods
Term:	3
Responsible person for the Module	Univ.-Prof. Dr.-Ing. Oliver Langefeld
Lecturers:	Dr. rer. nat. Nikolaos Polysos
Language:	English
Position within the Curriculum	Compulsory optional subject (WPF)

Course Type	**hpw**	**Work Load [h] Contact hours-/ Self-Study time**	**CP**	**Skills**			
				FK	**MK**	**SK**	**SOK**
Specialized Driving Methods	2	28/62	3	80	10	10	0

Requirements:	-
Learning objectives / Skills:	This course is intended to provide treatment for a sufficient roadway support design for the drivage and utilization phase at great mining depths. The topics would concentrate on more practice orientated engineering prespectives and take into account the complete roadway lifecycle. The following topics will be treated: Fundamental knowledge and practical application in geotechnical and geomechanical principles of strata and benefits of the rockmass classification. The effect of depth-related stress and additional load generated from mining activities and prediction of roadway convergence in consideration of geomechanical evaluation. Selection of the roadway development methods and mechanical equipment. Roadway support systems and elements, with emphasis on the rockbolt application as well as cementitious construction materials and techniques and process of grout/resin injection. Structured roadway planning process and support calculation methods. Function of various measuring instruments and roadway monitoring during development and use in frame of ground control.
Course Outline:	1. Geotechnical principles of strata control 2. Rock stress and stress field in multiple seam mining 3. Rock and roadway deformation 4. Heading and support systems 5. Roadway development and support design methods and calculations 6. Roadway monitoring
Assessments:	Written examination (60 min)
Media:	Oral presentation with powerpoint
Literature:	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) Handbock on Strata Control 146 p., CTP, Cape Town
Additional Information:	-

Module 18.2 Project Development in Underground Primary Production

Degree Programm:	M.Sc. Mining Engineering
Number of the Module	18.2
Name of the Module:	Project Development in Underground Primary Production
Course(s):	Project Development in Underground Mining considering operative and economic aspects
Term:	4
Responsible person for the Module	Univ.-Prof. Dr.-Ing. Oliver Langefeld
Lecturers:	Dr.-Ing. Thomas Hollenberg
Language:	English
Position within the Curriculum	Compulsory optional subject (WPF)

Course Type	**hpw**	**Work Load [h] Contact hours-/ Self-Study time**	**CP**	**Skills FK**	**MK**	**SK**	**SOK**
Project Development in underground mining considering operative and economic aspects (V+Ü)	2	28/62	3	50	30	10	10

Requirements:	-
Learning objectives / Skills:	Knowledge of tendering procedures, contract types and calculation basis; Evaluation of projects considering project and contract risk; assessment and comprehension of different contract types; calculation of budget and offers
Course Outline:	1. Progress of project development 2. Project charter 3. Contract types 4. Tendering procedures 5. Economic aspects 6. Type of costs and calculation of costs 7. Invitation for tender 8. Claim management
Assessments:	Written examination (90 min)
Media:	Oral presentation with powerpoint
Literature:	▪ Verdingungsordnung für Bauleistungen ▪ Honorarordnung für Architekten und Ingenieure ▪ Bürgerliches Gesetzbuch ▪ Bau-Geräte Liste ▪ Mine and Mill Equipment Costs 2012 ▪ Further literature follows during lecture
Additional Information:	-

Module 18.3 Underground Blasting

Degree Programme:	M.Sc. Mining Engineering
Number of the Module:	18.3
Name of the Module:	Underground Blasting
Course(s):	Underground Blasting and Explosives Engineering
Term:	4
Responsible persons for the module:	Univ.-Prof. Dr.-Ing. Oliver Langefeld
Lectures:	Dr.-Ing. Rüdiger Triebel
Language:	English
Position within the Curriculum	Compulsory optional subject (WPF)

Course Type	**hpw**	**Work Load [h] Contact hours-/ Self-Study time**	**CP**	**Skills**			
				FK	**MK**	**SK**	**SOK**
Underground Blasting (2V)	2	28/62	3	50	30	10	10

Requirements:	Basics knowledge about underground mining methods and mining processes
Learning objectives / Skills:	Underground Blasting and Explosives Engineering Underground blasting is embedded in quite complex international and national regulations and mine specific processes so that not only shot firers but also responsible mining engineers must have an according insight into this field. Participants of the course will be introduced into conventional mining by drill and blast methods and be enabled to understand the principles of underground blasting. Therefore historic data, basic definitions and the according legal framework are presented. This is followed by explanations regarding the nature of explosives and initiation systems. Participants will learn to understand and to layout underground drill and blast patterns. Development and application of different underground blasting methods is taught during the lectures, underground blast examples are analyzed. Participants will learn special safety awareness in explosives use.
Course Outline:	Underground Blasting and Explosives Engineering • Basics of underground blasting applications • Introduction into explosives regulations • Explosives and initiation systems • Blasting methods • Blasting emissions • Safety aspects
Assessment:	Oral or written Examination, duration 45 minutes (oral) or 90 minutes (written)
Media:	Presentations, basic calculations, demonstrations, videos
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.

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- Deutsche Gesetzliche Unfallversicherung e.V. : BGR/GUV-R 241 Regel Sprengarbeiten; Berlin; 2012.
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- 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.
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- Köhler, J.; Meyer, R.; Homburg, A.: Explosivstoffe; WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim; 2008.
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	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.
Additional Information:	Excursions to mines and possibly to explosives manufacturers to learn about the practical use of explosives in drill and blast operations.

Module 18.4 Software for Underground Mine Planning

Degree Programme:	M.Sc. Mining Engineering
Number of the Module	18.4
Name of the Module:	Software for Underground Mine Planning
Coruse(s):	Software for Underground Mine Planning
Term:	3
Responsible person for the module:	Univ.-Prof. Dr.-Ing. Oliver Langefeld
Lecturer:	Univ.-Prof. Dr.-Ing. Oliver Langefeld
Language:	English
Position within the Curriculum:	Compulsory optional subject (WPF)

Course Type	SPW	Work Load [h] Contact hours-/ Independant Studies	ECTS	Skills FK	MK	SK	SOK
Lecture Software for Underground Mine Planning (2V)	2	28/62	3	50	30	10	10

Requirements:	Underground Mine Planning
Learning objectives / Skills:	This course provides an introduction to planning software for underground mining activities. The learning objective include to apply the knowledge of the mine planning process. Students will be able to develop, design and model a complete mine layout on the basis of all available information as well as to identify, formulate, analyse and solve engineering problems resulting from the need to conduct underground 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.
Course Outline:	• Introduction Mine Planning Software • Basics • Borehole Information • Triangulation • Block Modeling • Underground Design • Project
Assessment:	Assignment (20%) and oral (30 min) or written examination (90 min, 80%)
Media:	Lecture (Activity-based Learning Approach), Beamer-Presentation, Skript, Laboratory (PC), Group and Project works
Literature:	• Darling, Peter, ed. SME mining engineering handbook. Vol. 1. SME, 2011. • Additional secondary literature-to be announced in the lecture.
Additional Information:	-

Module 18.5 Advanced Drilling Engineering II

Degree Programme:	M.Sc. Mining Engineering
Number of the Module:	18.5
Name of the Module:	Advanced Drilling Engineering
Course(s):	Underground Blasting and Explosives Engineering Advanced Drilling Technology II
Term:	4
Responsible persons for the module:	Univ.-Prof. Dr.-Ing. Oliver Langefeld PD Dr. Dr-Ing. habil. Catalin Teodoriu
Lectures:	PD Dr. Dr-Ing. habil. Catalin Teodoriu
Language:	English
Position within the Curriculum	Compulsory optional subject (WPF)

Course Type	**hpw**	**Work Load [h] Contact hours-/ Self-Study time**	**CP**	**Skills**			
				FK	**MK**	**SK**	**SOK**
Advanced Drilling Engineering II (2V)	2	28/62	3	50	30	10	10

Requirements:	Advanced Drilling Engineering I
Learning objectives / Skills:	Specialized knowledge of drilling technology, including machines and special application, other than oil and gas drilling Advanced Applications in the Drilling Practice outside oil and gas activities. Students will have the chance to perform live demonstration using hands on teaching equipment or building new setups to demonstrate their tasks. Additionally this course offers the opportunity to learn about team work
Course Outline:	Drilling fluids for HPHT Conditions Drilling for Diamonds Directional drilling with application for tunneling Drilling and Well Construction for Salt Caverns Salt Saturated cementing of wells Well Integrity Horizontal Directional Drilling Case Studies
Assessment:	Oral (30 min) or written (90 min) Examination
Media:	Presentations, demonstrations, videos
Literature:	List follows during lecture.
Additional Information:	-

Module 18.6 Natural Gas Storage in Rock Caverns

Degree Programme:	M.Sc. Mining Engineering
Number of the Module:	18.6
Name of the Module:	Natural Gas Storage in Rock Caverns
Course(s):	Natural Gas Storage in Rock Caverns
Term:	3
Responsible person for the module:	Univ. Prof. Dr.-Ing. habil. K.-H. Lux
Lecturers:	Univ. Prof. Dr.-Ing. habil. K.-H. Lux
Language:	English
Position within the Curriculum:	Compulsory optional subject (WPF)

Course Type	**hpw**	**Work Load [h]** **Contact hours-/ Self-Study time**	**CP**	**Skills** **FK**	**MK**	**SK**	**SOK**
Natural gas storage in rock caverns (2V)	2	28/62	3	60	40	0	0

Requirements:	Advanced Rock Mechanics
Learning objectives / Skills:	Thermodynamic and geomechanic principles of gas storage in salt and rock caverns. Geomechanical stability criteria (Prof. Lux), design, construction and operation of cavern storages
Course Outlines:	* 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
Assessments:	Written examination (90 min)
Media:	Lecture, beamer presentation, lecture notes
Literature:	given parallel to lecture, enclosed in lecture notes
Additional Information:	-

Module 18.7 Advanced Underground Mining

Degree Programme:	M.Sc. Mining Engineering
Number of the Module:	18.7
Name of the Module:	Advanced Underground Mining
Course(s):	Underground Mining – Special Applications
Term:	3
Responible person for the module:	Univ.-Prof. Dr.-Ing. Oliver Langefeld
Lecturer:	Univ.-Prof. Dr.-Ing. Oliver Langefeld
Language:	English
Position within the Curriculum:	Compulsory optional subject (WPF)

Course Type	**hpw**	**Work Load [h] Contact hours –/ Self-Study time**	**CP**	**Skills**			
				FK	**MK**	**SK**	**SOK**
Underground Mining – Special Applications (2V)	2	28/62	3	25	20	30	25

Requirements:	-
Learning objectives / Skills:	Explaining the specialities of very deep mining and deep sea mining Designing a hard rock / soft rock application in a mine with all important items (road heading, extraction, infrastructure, equipment) Explaining sustainability and exercise in different issues
Course Outline:	The course outline can vary over the years. They depend on actual developments and interest of the students. For example: a. Special requirements to very Deep Mining b. Sustainability c. Deep Sea Mining d. Mining in several countries e. Project f. Lecturs from partner universities
Assessments:	Assignment (homework, exercise, presentation) (25%) and Oral (30 – 40 min) or Written (90 min) examination (75%)
Media:	Oral presentation with Power Point, Exercises and discussions
Literature:	▪ Sme Mining Handbock ▪ Sustainable Management of Mining Operations ▪ Mining Engineering Analysis
Additional Information:	The course is possibly held in blocks because of different lecturers. The dates are announced at the beginning of the semester

Module 18.8 Underground Emergency Response I

Degree Programme:	M.Sc. Mining Engineering
Numberof Module:	18.8
Name of Module:	Underground Emergency Response I
Course(s):	Basics of Fire Protection and Mine Rescue
Term:	3
Responsible Person for the Module:	Univ.-Prof. Dr.-Ing. Oliver Langefeld
Lecturer:	Dr.-Ing. Walter Hermülheim
Language:	English
Position within the Curriculum:	Compulsory optional subject (WPF)

Course Type	**SWS**	**Work Load [h] Contact hours-/ Independent studies**	**ECTS**	**Skills**			
				FK	**MK**	**SK**	**SOK**
Basics of Fire Protection and Mine Rescue (2L)	2	28/62	3	50	30	10	10

Requirements:	Underground work experience (internship). Basic knowledge of mine layout, mineral extraction and ventilation methods in coal and non coal mining.
Learning objectives/ Skills:	Develop an understanding for necessities, logical relations and methods concerning the prevention of catastrophic accidents in mining (FK/ SK). Enable a production engineer to act safely and properly in case of an unexpected mine emergency (MK/ SOK).
Course Outline:	Basics of Fire Protection and Mine Rescue: Fire prevention and detection, means of fire fighting, manual fire fighting, fires and ventilation, sealing off fires, fire fighting with inert gases, explosion risks. Organization and training of mine rescue brigades, noxious gases underground, gas detection, breathing protection, equipping a mine rescue brigade, emergency and operational mine rescue work, incl. climate and explosive gases rules. Underground self rescue and escape. Group exercises: Basics of risk analysis, methane dilution in a blind drift, measures during the first hour of a mine emergency.
Assessment:	Written examination *(120 min).*
Media:	Presentations, tuition talks, group exercises. Lecture notes & selected current publications & bibliography as pdf-download.
Literature:	▪ Hermülheim, W. et al.: Handbuch für das Grubenrettungswesen im Steinkohlenbergbau *(Colliery Mine Rescue Handbook, in German).* Essen, VGE-Verlag, 2007. ▪ Mitchell, D.: Mine Fires – Prevention, Detection, Fighting. Chicago, McLean-Hunter, 1990. ▪ Ramlu, M. A.: Mine Disasters and Mine Rescue. Rotterdam, A. A. Balkema, 1991. ▪ Strang, J./ MacKenzie-Wood, P.: A Manual on Mines Rescue, Safety and Gas Detection. Woonona, Austcue Publishers, 1985. ▪ Hermülheim, W.: Organization and Training of Volunteer Mine Rescue Brigades. 32nd Int. Conference of Safety in Mines Research Institutes, Beijing, 2007, P. 393/397. ▪ Hermülheim, W.: Zen and the Art of Mine Rescue. 6th Int. Symposium on High Performance Mining, Aachen, RWTH, 2014, P. 385/398 *(also see reprint in Mining Report Glückauf 150 (2014), P. 265/276).* ▪ Martens, P. N./ Hermülheim, W.: Disaster Prevention in Deep Hard Coal Mining – A German Review. SME Annual Meeting, Phoenix, AZ, 2010, S. 308/313. ▪ Breslin, J. A.: One Hundred Years of Federal Mining Safety and Health

	Research. US-Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Pittsburgh, PA, 2010. ▪ Noxious Gases Underground. A Handbook for Colliery Managers. National Coal Board, Scientific Control, Harrow, 1973. ▪ Hornsby, C. D. et al.: Sealing-off Fires Underground. Institution of Mining Engineers, Doncaster, 1985. ▪ Hermülheim, W./ Bresser, G.: New Breathing Apparatus for the German Coal Industry. Glückauf Mining Reporter I/ 2006, S. 30/35. ▪ Bresser, G./ Kampmann, B.: Working-Time Standards for Mine Rescue Operations under Hot and Wet Ambient Conditions in German Coal Mines. Int. Conference on Mine Rescue Works, Bytom, 2000. ▪ Hermülheim, W./ Betka, A.: Cutting down Production Loss after Mine Fires and Explosions. Glückauf Mining Reporter I/ Apr. 2010, S. 31/34. Additional selected literature on mine safety, e. g. regulations, conference papers, and mine rescue handbooks/ training materials available online: ▪ esb.bezreg-arnsberg.nrw.de *(in German)* ▪ www.securmine.net ▪ www.atemschutzzentrum.net *(in German)* ▪ www.cdc.gov/niosh/mining ▪ www.deutsche-grubenrettung.de *(in German)* ▪ www.hauptstelle.at *(in German)* ▪ www.hse.gov.uk ▪ www.lrws.gov.sk.ca ▪ www.minerescue.org ▪ www.minesrescue.co.za ▪ www.msha.gov/MineRescue ▪ www.qrc.org.au/conference ▪ www.usmra.com ▪ www.workplacesafetynorth.ca
Additional Information:	Block course *(4 days)*

Module 18.9 Underground Emergency Response II

Degree Programme:	M.Sc. Mining Engineering
Numberof Module:	18.9
Name of Module:	Underground Emergency Response II
Course(s):	Specific Topics of Fire Protection and Mine Rescue
Term:	4
Responsible Person for the Module:	Univ.-Prof. Dr.-Ing. Oliver Langefeld
Lecturer:	Dr.-Ing. Walter Hermülheim
Language:	English
Position within the Curriculum:	Compulsory optional subject (WPF)

Course Type	**SWS**	**Work Load [h] Contact hours-/ Independent studies**	**ECTS**	**Skills**			
				FK	**MK**	**SK**	**SOK**
Specific Topics of Fire Protection and Mine Rescue (2L)	2	28/62	3	50	30	10	10

Requirements:	Underground work experience (internship). Basic knowledge of mine layout, mineral extraction and ventilation methods in coal and non coal mining.
Learning objectives/ Skills:	Develop an understanding for necessities, logical relations and methods concerning the prevention of catastrophic accidents in mining (FK/ SK). Enable a production engineer to act safely and properly in case of an unexpected mine emergency (MK/ SOK).
Course Outline:	Specific Topics of Fire Protection and Mine Rescue: Recap of basics lecture, designing and equipping a mine rescue station, breathing apparatus for special purposes, rescue of entrapped persons, communication and stress during mine rescue operations, public relations and press work. Explosion protection and explosive dust control in collieries. Spontaneous combustion fire guideline, underground nitrogen and mortar matter supply, rigid foam processing, design of fire extinguishing systems, gas testing and gas analysis, Graham's Ratio and Coward-Diagrams, control of explosion prone fires. Tunnel fire safety, mine safety in developing countries. Group exercises: Examples of operational mine rescue work, underground incident scenarios, fighting a spontaneous combustion fire.
Assessment:	Written examination *(120 min).*
Media:	Presentations, tuition talks, group exercises. Lecture notes & selected current publications & bibliography as pdf-download.
Literature:	▪ Hermülheim, W. et al.: Handbuch für das Grubenrettungswesen im Steinkohlenbergbau. *(Colliery Mine Rescue Handbook, in German).* Essen, VGE-Verlag, 2007. ▪ Mitchell, D.: Mine Fires - Prevention, Detection, Fighting. Chicago, McLean-Hunter, 1990. ▪ Ramlu, M. A.: Mine Disasters and Mine Rescue. Rotterdam, A. A. Balkema, 1991. ▪ Strang, J./ MacKenzie-Wood, P.: A Manual on Mines Rescue, Safety and Gas Detection. Woonona, Austcue Publishers, 1985. ▪ Michelis, J.: Explosionsschutz im Bergbau unter Tage *(Underground Explosion Protection, in German).* Glückauf Betriebsbücher, Band 38. Essen, Verlag Glückauf, 1998. ▪ Kissell, F. N.: Handbook for Methane Control in Mining. US-Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Pittsburgh, PA, 2006.

- Kissell, F. N.: Methane Control in Tunneling. US Dept. of the Interior, Bureau of Mines, Washington, DC, 1989.
- Kissell, F. N.: Handbook for Dust Control in Mining. US-Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Pittsburgh, PA, 2003.
- Hermülheim, W./ Beck, K.-D.: Inertization as Means for Reducing Down-Time and the Explosion Risk in Cases of Spontaneous Combustion. 6th Int. Mine Ventilation Congress, Pittsburgh, PA, 1997, S. 299/303.
- Hermülheim, W./ Bolesta, M.: Examples of Grouting Techniques in Operational Applications. 6th Int. Symposium on Rockbolting in Mining & Injection Technology and Roadway Support Systems, Aachen, RWTH, 2008, P. 205/224.
- MacKenzie-Wood, P./ Strang, J.: Fire Gases and their Interpretation. The Mining Engineer 149 (1990), S. 470/478.
- Hein, N./ Hermülheim, W./ Fuchs, E./ Culmann, J. et al.: Beurteilung der Analysenergebnisse von Grubenbrandgasproben *(Mine Fire Gas Analysis, in German)*. Pirrot, Saarbrücken, 1995.
- 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. Part 2: Safety Management Systems, Safety Training and Pilot Projects. Glückauf Mining Reporter, III/ Oct. 2009, S. 44/48.
- Hermülheim, W.: Evaluation of Hard Coal Mines in Emerging Nations in Terms of Mine Safety. AMS Advanced Mining Solutions Online 03/ 2011 *(www.advanced-mining.com),* S. 25/34.
- Langer, G./ Hermülheim, W./ Bresser, G.: Better Fire and Explosions Prevention and Improved Mine Rescue in Hard Coal Mining of Countries in Transition to Industrialization. 27th Int. Conference of Safety in Mines Research Institutes, New Delhi, 1997, S. 457/469.

Additional selected literature on mine safety, e. g. regulations, conference papers, and mine rescue handbooks/ training materials available online:

- esb.bezreg-arnsberg.nrw.de *(in German)*
- www.securmine.net
- www.atemschutzzentrum.net *(in German)*
- www.cdc.gov/niosh/mining
- www.deutsche-grubenrettung.de *(in German)*
- www.hauptstelle.at *(in German)*
- www.hse.gov.uk
- www.lrws.gov.sk.ca
- www.minerescue.org
- www.minesrescue.co.za
- www.msha.gov/MineRescue
- www.qrc.org.au/conference
- www.usmra.com
- www.workplacesafetynorth.ca

Additional Information:	Block course *(4 days),* incl. 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)*

Module 18.10 Sustainability in Underground Mining

Degree:	M.Sc. Mining Engineering
Number of the Module:	18.10
Name of the Module:	Sustainability in Underground Mining
Course(s):	Sustainability in Underground Mining
Term:	4
Responsible Person for the Module:	Univ.-Prof. Dr.-Ing. Oliver Langefeld
Lecturer:	NN
Language:	English
Position within the Curriculum:	Compulsory optional Subject (WPF)

Course Type	**hpw**	**Work Load [h] Contact hours-/ Self-Study time**	**CP**	**Skills**			
				FK	**MK**	**SK**	**SOK**
Sustainability in Underground Mining	2	28/62	3				

Requirements:	-
Learning objectives / Skills:	Understanding sustainability and the importance of it; Current state of art of sustainability in mining; Providing the basics to lead the students to think about sustainability in the mining industry; Improving presentation skills
Course Outline:	Discussion of the concept of sustainability and the understanding of it; Overview of sustainability in the mining sector; Concepts related to sustainability; Case study with LCA (Life Cycle Assessment) based on social, environmental and economic factors and theoretical foundations; Current policy in Europe; Discussion of benefits and drawbacks of the development
Assessement	Assignment (homework, exercise, presentation) (25%) and Oral (30 – 40 min) or Written examination (90 min, 75%)
Media:	lecture, projector-presentation, lecture notes
Literature:	Will be given in the lecture
Additional Information:	The course is possibly held in blocks. The dates are announced at the beginning of the semester