Study Handbook

International Master of Science in Advanced Mineral Resources Development

(Joint Master Degree Program)

6th Edition, June 2018

Dear Students of the Joint Master Degree Program “Advanced Mineral Resources Development”,

this Study Handbook provides an overview on the complete courses of the Joint Master Degree Program “Advanced Mineral Resources Development”.

It should not only give you a detailed outline on the content of the program, but also assist you when registering for a course. It describes the topics, learning outcomes and any prerequisites you might need.

In case you have any questions do not hesitate to contact us!

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We wish you good luck for your studies!

Glückauf

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Program Structure

Advanced Mineral Resources Development is a Joint Master Degree Programme between Montanuniversitaet Leoben (Austria) and TU (Technische Universitaet) Bergakademie Freiberg (Germany) and a four partner universities. Students study the first semester at Montanuniversitaet Leoben, the second semester at TU Bergakademie Freiberg and the third semester at either Montanuniversitaet Leoben, TU Bergakademie Freiberg or one of the partner universities. The fourth semester is for the preparation of the master's thesis. The language of instruction is English. Current partner universities are

- National Technical University Dnipro Polytechnic, Ukraine
- China University of Mining and Technology Beijing, China
- Amirkabir University of Technology Tehran, Iran
- The Instituto Superior Técnico of the Universidade de Lisboa, Portugal.

Students may propose to pass the third and fourth semester at a different international mining university. For this, prior approval from the program director is required.

The joint master degree program AMRD comprises compulsory subjects (72 ECTS), restricted electives (12 ECTS), free electives (6 ECTS), the master thesis and the final exam for the master’s degree.

	ECTS
Compulsory subjects	72
Restricted electives	12
Free electives	6
Master thesis	25
Presentation and final exam of the master thesis	5
Sum	120

Compulsory subjects

The compulsory subjects consist of the following areas

- Mineral Economics and Project Management (24,5 ECTS), Montanuniversitaet Leoben
- Mining and Environment (24 ECTS), Technische Universität Bergakademie Freiberg
- Mining Technology (23,5 ECTS), either Montanuniversitaet Leoben or Technische Universitaet Bergakademie Freiberg or one of the AMRD partner universities

Restricted electives

The restricted electives cover 12 ECTS, whereas at least 3 ECTS have to be completed at each of the universities.

Free electives

Free electives cover 6 ECTS and can be chosen from any officially recognized university. It makes sense to choose ones free electives from the lists of the restricted electives

The AMRD program covers 120 ECTS points. This corresponds to the usual study period of four semesters (two years). In each semester 30 ECTS points are usually acquired.

All students complete the first semester of the master program at Montanuniversitaet Leoben, the second semester at TU Bergakademie Freiberg, and the third semester either at Montanuniversitaet Leoben, TU Bergakademie Freiberg or at one of the partner universities. The fourth semester, which is usually set aside for the delivery of the master's thesis, can be completed at Montanuniversitaet Leoben, TU Bergakademie Freiberg or at a partner university. This study order is compulsory for all students.

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1. Montanuniversitaet Leoben

1. 1 Compulsory Subjects

Computer Applications in Mining

Course Nb	200.208
Credits	2,5
Type	Lecture / Practical
Lecturer	Oberndorfer
Course description	
Content	• Overview of main fields of computer application in mining • Overview of mathematical tools applied, in particular optimization • Calculation models, relation reality – model, requirements, constraints • Ultimate pit (LG): basic assumptions, optimization goal • Consequences of LG model on practical application (time, blending, ramps, reasonable pit geometry) • Solution strategy Zhao-Kim • Mine sequencing: optimization goals, heuristics • Truck dispatching: optimization goals, system requirements
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Basic knowledge of open pit mining

Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to • Understand the potential contribution of discussed methods on mine design and mine operation • Understand the requirements, threats and constraints of these methods
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lecture Active participation and discussion
Further information	
Recommended reading	
Note	The assessment methods and the compulsory readings of this course will be announced in detail in the first lecture. The latest version of the lecture notes will be uploaded at the beginning of the semester.

Deposit Modeling

Course Nb	200.060
Credits	3
Type	Lecture
Lecturer	Haindl, Oberndorfer
Course description	
Content	• Goals of deposit modeling • General principles of modeling • Representation techniques: surface and volume/property models • Interpolation methods incl. introduction to geostatistics • Raw data handling (introduction databases) • Integration of modeling into mining operation (panning/forecast, validation) • The practical part: software based modeling and mine planning
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Basic knowledge on geology (deposit types and characteristics), statistics and open pit mining (interaction mining/deposit)
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to • Understand the principle of creating geological and geometrical models • Use the basic tools of the mine planning software • Know fundamental methods available and their pro and cons

	• Design and introduce deposit modeling for a mine operation, in particular knowing the essential aspects to be considered • Analyze block models and calculate reserves and resources. • Create a 3D open pit design
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Theoretical part: lecture Practical part: covers demonstration with short exercises on real data and a homework assignment with final presentation
Further information	
Recommended reading	
Note	The assessment methods and the compulsory readings of this course will be announced in detail in the first lecture. The latest version of the lecture notes will be uploaded at the beginning of the semester.

Economic Geology and Mining Economics

Course Nb	200.050
Credits	6
Type	Lecture
Lecturer	Haindl
Course description	
Content	• Introduction • Economic Geology (deposit as factor of production) o Basics o Prospection and exploration o Reserves and Resources o Documentation of a deposit o European strategy on raw materials, Mining laws • Factors of production – labour o Basics o Influencing factors o Cost factor labour • Means of production (incl. energy) o Legal requirements o Requirements (Benefit/Costs, Life time, availability, utilization, procurement) o Energy • Cost accounting o Internal cost calculation (cost-type, cost-centre, cost-unit) o Budgeting and direct costing o External cost calculation (balance sheet, P&L)

	• Profitability and investment
	  o Terms and basics
	  o Static investment calculations
	  o Dynamic investment calculations
	  o Evaluation
	• Risk and sensitivity analysis

Previous knowledge expected	• Good English skills (Minimum: CEF Level B1)
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to: • Understand the basics of economic systems • Understand the special conditions of the mining industry • Classify reserves and resources • Describe the factors of production • Understand the basics of cost calculation, profitability and investment
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lecture Discussions Active participation and interaction are supported
Further information	
Recommended reading	
Note	The assessment methods and the compulsory readings of this course will be announced in detail in the first lecture. The latest version of the lecture notes will be uploaded at the beginning of the semester.

Geoinformatics

Course Nb	200.185
Credits	2,5
Type	Lecture / Excercise
Offering period	Wintersemester
Lecturer	Mayer
Course description	
Content	• Introduction into the methods and concepts of spatial informatics and some applications in the mineral extraction industry. Practical work using software tools.
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1)
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to: • Visualize spatial data, as used in the mineral resources industry with software tools • Perform simple analyzes and calculations, such as resource estimations.
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lectures Active participation, discussions
Further information	
Note	The assessment methods and the compulsory readings of this course will be announced in detail in the first lecture. The latest version of the lecture notes will be uploaded at the beginning of the semester.

Lab in Mining Engineering

Course Nb	200.052
Credits	3
Type	Practical
Lecturer	Heiss, Seidl
Course description	
Content	• Mine Visit • Rock Mass Classification on site • Rock sample preparation • Rock testing in the lab • Interpretation of results • Stability calculations (based on the developed parameters) • Preparing a scientific report • Presentation of the results
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Sustainable knowledge in the following fields - successful completion of the following lectures: o Mining Rock Mechanics (200.179) o Underground Mining (200.036) • Practical experience in an underground mine!
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to • Merge the acquired knowledge from the lectures Rock Mechanics and Underground Mining. • Work independently! • Carry out a rock mass classification after Barton, Hoek, Bieniawski & Laubscher on the mine site • Prepare a rock sample in the lab

	• Carry out rock tests in the lab (UCS,…) • Calculate and interpret the acquired results • Carry out stability calculations for an underground situation
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	• Lectures • Underground mine visit (1day) • Active participation • Group sessions with the lecturer
Further information	
Recommended reading	• Brady & Brown: Rock Mechanics for underground mining. 2004. Print ISBN: 1-4020-2064-3.
Note	Will be held in the sense of a “practical course”. Participants have to prepare and test “their” rock sample! This is the base for the stability calculations. The assessment methods and the compulsory readings of this course will be announced in detail in the first lecture. The latest version of the lecture notes will be uploaded at the beginning of the semester.

Mineral Economics

Course Nb	200.193
Credits	3
Type	Lecture
Lecturer	Drnek
Course description	
Content	• Theory of mineral demand • Determinants of mineral demand • Demand functions, elasticities of demand, supply-cost functions of mineral resources and secondary materials • Competitive vs. producer markets • Factors affecting mineral prices, commodity exchanges, objectives and instruments of mineral policy • Long-term trends on mineral markets • Statistics of energy resources and mineral commodities. • The raw-material commodities are introduced in detail.
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Good general knowledge is helpful
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to • Understand the connections and events on raw material markets • Know the fundamentals for analyses of the raw material markets • Impart knowledge in the field of raw material policies and trade

Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	• Intensive and permanent active participation; i.e.: presentations, pre-reading assignments • Critical analysis and argument of the presented material Teaching and learning method • Presentation of theory and practical examples • Question and answer session • Discussion • Analysis of current economic situation
Further information	
Recommended reading	• Britton S. et al: Minerals Economics. In: Mining Engineering Handbook, SME (2nd ed., Vo.1),p. 43 – 139 • Fettweis G.B.: Der Produktionsfaktor Lagerstätte. In: Die elementaren Produktionsfaktoren des Bergbaubetriebs. Band 1 • Gschwindt, E.: Projektierung von Bergwerken im Ausland, In: Die Wirtschaftlichkeit und Bewertung im Bergbau. Band III • Von Wahl: Bergwirtschaft Band I bis III • Von Wahl: Wirtschaftliche Bewertung von Lagerstätten und von Bergwerksunternehmen. In: Die Wirtschaftlichkeit und Bewertung im Bergbau. Band III • Business- and Financial section of the following newspapers: Frankfurter Allgemeine Zeitung Neu Zürcher Zeitung Süddeutsche Zeitung

	Financial Times The Times: London and New York • Reference Books: Gabler: Wirtschaftslexikon • Further Reading: Annual Report Rio Tinto (Internet) Annual Report BHP (Internet)
Note	The assessment methods and the compulsory readings of this course will be announced in detail in the first lecture. The latest version of the lecture notes will be uploaded at the beginning of the semester.

Mining in Austria, in the European Union and worldwide

Course Nb	200.140
Credits	1,5
Type	Lecture
Lecturer	Hartlieb
Course description	
Content	• Mining Industry in Austria and the EU • Securing Supply of Mineral Resources in Europe • Construction Aggregates in Europe • World View on Mineral Production • Artisanal and Small Scale Mining • Economic Outlook in Mining • Innovation in Mining • Operational Excellence Framework in Mining • Different Presentations by national and international mining executives
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Basic knowledge in mineral economics • Main economic drivers in the mining industry
Objective (expected results of study and acquired competences)	On completion of this lecture the participants shall be able to have a good comprehension of: • The mining industry in terms of production and economic outlook • Demand and supply of mineral resources • Critical future issues in the mining industry • European mineral policies • Operational Excellence Framework

Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lectures, presentations, active participation and discussions
Further information	
Recommended reading	• British Geological Survey: World Mineral Production 2002 – 06/ L.E. Hetherington et.all. – Keyworth, Nottingham: British Geological Survey, 2008 • Ekdahl, E.: Mineral Resources in Europe, Presentation, International Symposium on the Planet Earth, Trondheim, 7-8 February 2008 • Nötstaller, R.: Patterns of Mineral Demand and supply global and regional perspectives, in: BHM – Berg- und Hüttenmännische Monatshefte, 147/2002, H.12, p.402 ff • Website of the European Union: Raw Materials
Note	The assessment methods and the compulsory readings of this course will be announced in detail in the first lecture. The latest version of the lecture notes will be uploaded at the beginning of the semester.

Seminar in Mining Engineering and Mineral Economics 1

Course Nb	200.043
Credits	1,5
Type	Seminar
Lecturer	Hartlieb
Course description	
Content	• Introduction to scientific writing • Presentation of the Guideline for Scientific Writing from the Chair of Mining • Systematic literature research • Proper handling and citation of literature • Development of structure and contents of a scientific report or thesis • Writing a scientific report about a mining-related topic from given literature sources
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1)
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to: • Write a scientific report • Look for information systematically • Reference correctly • Structure, layout and format a scientific paper / report
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lectures Exercises in-class with active participation of the students Assignment: writing a report

Further information	
Recommended reading	• Guideline for Scientific Writing, Chair of Mining Engineering and Mineral Economics, Montanuniversitaet
Note	The assessment methods and the compulsory readings of this course will be announced in detail in the first lecture. The latest version of the lecture notes will be uploaded at the beginning of the semester.

Surpac Introduction

Course Nb	200.009
Credits	2
Type	Lecture / Practical
Lecturer	Oberndorfer
Course description	
Content	• Mine planning software – capabilities and applications • Data structure, viewing, display, graphical appearance, property inquiry (interactive working) • Basic data (1d/2d objects, points/lines): editing, import, manipulation (polygon intersection) • Surfaces (s3d): generation, intersections, clipping, volumes, etc. • Surfaces (f3d, solids): generation, intersection, volumes, etc. • Block models (property model): generation, assigning block values (surfaces, simple interpolation), analysis using BM (reporting, constraints) • Geological databases: concept, Surpac-3rd party products interface, viewing, data extraction • Open pit and underground design: tools assisting mine design
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • This course focuses on software skills; no particular basic knowledge required

	• Knowledge in geology and mining, mathematical geometry and spatial sensing is advantageous but not mandatory
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to • Use Surpac for typical educational tasks such as a diploma thesis or project work and later during professional career. Sound basis for further enhancing skills while working with Surpac • Have a good overview on what mine planning software can do and have rough idea on effort (worktime) required for specific tasks.
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Students have to perform an exam exercise independently and present the result.
Further information	
Recommended reading	
Note	The assessment methods and the compulsory readings of this course will be announced in detail in the first lecture. The latest version of the lecture notes will be uploaded at the beginning of the semester.

1. 2 Restricted Electives

Excavation Engineering

Course Nb	200.059
Credits	2,5
Type	Lecture/Practical
Lecturer	Hartlieb, Sifferlinger
Course description	
Content	This is a general course about rock blasting and how it is used in mining and civil engineering. The following topics will be covered: • Basics of explosives engineering • Blast fragmentation control • Blasting in drifts and tunnels • Design of an underground drift blast • Cautious blasting • Sinking of shafts and development raises • Underground production blasting • Alternative fragmentation methods • Visit to industry (if possible):
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Basic Engineering Physics and Math (e.g. logarithms and power functions, equations, integrals, function analysis) • Basic Mining Engineering • Rock Mechanics
Objective (expected results of study and acquired competences)	On completion of this course the participants shall know about • The role of rock blasting in raw materials extraction

	• The properties and proper use of explosives and initiation devices in rock blasting • Fragmentation; how to describe it and factors that influence it • Outlines about environmental influence of blasting like ground vibrations, fly rock and noxious gases • Different types of tunnel rounds and how to design in detail a tunnel round with a parallel hole cut • Blast damage in excavation contours and design principles to minimize this in tunnels and road cuts • Outlines of shaft sinking and raise driving • Different methods used in underground production blasting for various mining methods and required charging • Outlines of breakage methods like water jets, micro waves etc.
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lectures Group assignment, 2-3 students working together. (Design of an underground drift blast) Oral examinations Lecture attendance

Further information	
Recommended reading	Lecture notes in pdf format
Note	The assessment methods and the compulsory readings of this course will be announced in detail in the first lecture. The latest version of the lecture notes will be uploaded at the beginning of the semester.

Excursion

Course Nb	200.198
Credits	2
Type	Field Trip
Offering period	***Summer***semester
Lecturer	Hartlieb
Course description	
Content	• Visits of mining operations in Austria, in the European Union and overseas as an additional training to the theoretical study program at the university • Discussions with mine managers about the organization of mining operations and the planning of new mines.
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Bachelor in Mineral Resources Engineering or Applied Geosciences is essential. • Detailed knowledge of open pit- and underground mining methods • Knowledge of mine organization
Objective (expected results of study and acquired competences)	• Application of previously gained knowledge. • Comparison of theoretical knowledge and application case. • Comprehensive insight of entire mining operations from technological to economic aspects, from mining to processing.
Languages of instruction	English

Teaching and learning method (delivery of skills) workload for students	• Mine visits and tours • Talks to mine managers and discussion with persons in charge • Active preparation of the tour points • Final report after the excursion.
Further information	
Recommended reading	Will be updated on the website according to the specific dates and tour points of the excursion.
Note	The assessment methods and the compulsory readings of this course will be announced in detail in the first lecture. The latest version of the lecture notes will be uploaded at the beginning of the semester.

Feasibility Study 2

Course Nb	200.049
Credits	3
Type	Project work
Offering period	Wintersemester
Lecturer	Hartlieb, Mali
Course description	
Content	On basis of “Feasibility Study 1 (200.048)” the students finalize their project. A joint project plan was set up at the beginning of “Feasibility Study 1”. This project plan is updated and open points and milestones are solved during this lecture. Students write a technical report and present milestones and final results in front of the industrial project owner.
Previous knowledge expected	• **Participation in Feasibility Study 1 (200.048)!** • Good English skills (Minimum: CEF Level B1). • BSc in Mining Engineering or related fields of study and / or proof of advanced knowledge and skills in the areas of: o Open pit mining o Underground mining o Geology o Environmental issues of mining o Mine planning o Mining geomechanics • Use of mine planning software (e.g. Surpac, Datamine) • Ability to independent and self-reliant work • Ability to structure, plan and perform a complex task in a group

	• Ability to write a scientific study report • Ability to present findings / results in front of a English speaking audience
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to: • Approach a technical challenge successfully • Set-up a project plan and handbook • Solve practical challenges of a future mining engineer • Organize the documents, data, tools, equipment, etc. for performing the assigned task • Apply their theoretical knowledge to solve a mining or geological problem • Present complex results to the management board of the company
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	• Self-sufficient / self-reliant and group work • Regular guidance meetings • Periodical status reports (oral) • Presentation of the final results (oral) • Compiling results to a final report (written)
Further information	
Note	The assessment methods and the compulsory readings of this course will be announced in detail in the first lecture. Grading is based on intermediate (30%) and final presentations (40%) and final report (30%). The latest version of the lecture notes will be uploaded at the beginning of the semester.

German as a foreign language basic level 1 - A1.1

Course Nb	641.112
Credits	4
Type	Lecture / Practical
Lecturer	Unterhauser
Course description	
Content	• Vermittlung von Grundvokabular und -syntax. Sprechen anhand von Alltagssituationen mit Hilfe eines Lehrbuchs (Berücksichtigung des D-A-CH Prinzips). • Landeskundliche Aspekte • Aussprachetraining mit Spracherkennungssoftware.
Objective (expected results of study and acquired competences)	Die Studierenden können • eine einfache Interaktion und Situation mit beteiligten Personen und Dingen beschreiben, • sich vorstellen, ihre Familienmitglieder und deren Beruf benennen und ihr Studium angeben. Sie können sagen, woher sie kommen, welche Sprache sie sprechen und welche Dinge sie besitzen, welchen Sport sie betreiben und wie sie ihre Freizeit gestalten, • ihren Tagesablauf darstellen, • kleine Geschichten aus dem Lehrbuch nacherzählen • und Fragen dazu stellen und beantworten, • Angaben mit Zahlen, Namen, Zeitangaben machen und verstehen, • kurze Notizen verfassen.
Languages of instruction	German

German as a foreign language basic level 3 - A2.1

Course Nb	641.000
ECTS	4
Type	Lecture/Practical
Lecturer	Unterhauser
Course description	
Content	• Wiederholen und Festigen der Kenntnisse auf Niveau A1.2 • Ausbau von Grundvokabular und –syntax in den Bereichen Ernährung, Restaurant, Wohnen, Möbel und Sport • Sprechen anhand von Alltagssituationen mit Hilfe eines Lehrbuchs (Berücksichtigung des D-A-CH-L Prinzips) • Näherbringen von landeskundlichen Aspekten mit besonderer Berücksichtigung der österreichischen Kultur • Aussprachetraining mit Spracherkennungssoftware.
Previous knowledge expected	• Basic German skills (Level A1.2)
Objective (expected results of study and acquired competences)	Die Studierenden können • alltägliche Interaktion und Situation mit beteiligten Personen und Dingen beschreiben • Dialoge in Supermarkt und in Restaurants führen • Einladungen an andere aussprechen • allgemeine Tätigkeiten im Haushalt beschreiben und darüber berichten • Personen beschreiben • eigene Wünsche sowie Vorlieben benennen • Bilder beschreiben

	• komplexe Geschichten aus dem Lehrbuch überblicksmäßig erfassen und nacherzählen • Befehle und Wünsche aussprechen • aHaupt- und Nebensätze bilden und diese gezielt einsetzen • kurze Briefe und Einladungen verfassen
Languages of instruction	German

Marine Mining

Course Nb	200.042
Credits	1,5
Type	Lecture
Lecturer	Groß, Wamser
Course description	
Content	• Introduction in marine mining • Marine mining methods • Overview of marine mineral deposits • Geology and mining methods for different raw materials • Environmental impact • Marine mining regulations • International law of the sea • International dispute resolution • Safety regulations for offshore employment
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Basics of mechanical excavation methods, geology and mineralogy
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to • Know the principles of marine mining methods depending on different geological requirements • Have a basic understanding of legal requirements for marine mining activities • Assess potential legal problems and know mechanics for dispute resolution
Languages of instruction	English

Teaching and learning method (delivery of skills) workload for students	Lectures Active participation and discussion
Further information	
Note	The assessment methods and the compulsory readings of this course will be announced in detail in the first lecture. The latest version of the lecture notes will be uploaded at the beginning of the semester.

Mining Subsidence Engineering

Course Nb	200.045
Credits	3
Type	Lecture
Offering period	Wintersemester
Lecturer	Pilgram
Course description	
Content	• Legal issues applied to mining subsidence engineering especially the pre-calculation of ground subsidence • The dynamics of ground movement and the critical areas of extraction in a subsidence trough after Lehmann • Calculation of trough components • Some varieties of calculation procedure • Measures to reduce mining damage • The components of ground movement • The time factor • Mining damage above ground • Compensation of subsidence damage • The calculation of diminished value
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1)
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to: • plan, implement and evaluate the pre-calculation of Ground Movements with some simple different methods. • plan, assemble and analyze deformation profiles and monitoring networks of ground movements

	• know the basics about the legal relationship between mining and land ownership • calculate the diminished value • plan and implement measures to reduce mining damage • share the costs for damage from two or more mines.
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lectures Active participation, discussions Practical examples
Further information	
Recommended reading	Kratzsch, H.: Bergschadenkunde, ISBN 3-00-001661-9 Kratzsch, H.: Mining Subsidence Engineering, ISBN 0-387-11930-2 Pilgram, R.: Lehrbehelf zur Vorausberechnung von Bodenbewegungen, The Precalculation of Ground Subsidence, Chair of Mining, Montanuniversitaet Leoben
Note	The assessment methods and the compulsory readings of this course will be announced in detail in the first lecture. The latest version of the lecture notes will be uploaded at the beginning of the semester.

Mine Surveying Project Study

Course Nb	200.032
Credits	4,5
Type	Project Work
Offering period	Wintersemester
Lecturer	Mayer, Pilgram
Course description	
Content	• Project study on various topics in the field of Mine Surveying and Mining Subsidence Engineering
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Successful completion of the courses o Applied Geodesy (200.199) o Applied Geodesy Practical (200.200) o Engineering Surveying (200.201) o Engineering Surveying Practical (200.202) o Pre-Calculation of Ground Movements (200.028)
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to: • Structure the project, define the sequence with milestones and form working groups • Combine interdisciplinary knowledge from mine surveying and mining subsidence engineering on a practical topic
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Practical teamwork

Further information	
Recommended reading	Ghilani, C. D., Wolf, P., Elementary Surveying Kratzsch, H.: Bergschadenkunde, ISBN 3-00-001661-9 Kratzsch, H.: Mining Subsidence Engineering, ISBN 0-387-11930-2 Möser, Müller, Schlemmer, Werner: Handbuch Ingenieurgeodäsie- Grundlagen; 3.Auflage; ISBN 3-87907-293-0 Torge, W., Müller, J.: Geodesy; 4th edition; ISBN 978-3-11-020718-7
Note	The assessment methods and the compulsory readings of this course will be announced in detail in the first lecture. The latest version of the lecture notes will be uploaded at the beginning of the semester.

Mine Ventilation

Course Nb	200.055
Credits	3
Type	Lecture
Lecturer	Sifferlinger
Course description	
Content	• Repetition of the basics of mine ventilation from BSc program including mine climate • Context of mine ventilation in the frame of mine design and layout • Basics of air flow mechanics and relevant physical laws • Basics and principles of mine ventilation including air flow principles in underground mining including ventilation laws • Analytical mine ventilation calculations • Numerical mine ventilation calculations, demonstration of ventilation software • Secondary ventilation including design and layout
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Mathematics 1 (380.110) • Physics of airflow • Basics of Underground Mining (200.180)
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to • Understand why it is important to have a proper mine ventilation system • Know the work safety risks associated with insufficient mine ventilation

	• Apply principles of air flow physics to mine ventilation problems • Do analytical calculations of simple ventilation networks • Understand the algorithm which is typically used in mine ventilation software packages • Do the design and layout of a secondary ventilation system • Understand the influence of design parameters of secondary ventilation on the ventilation results
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lectures Homework calculations Active participation and discussion
Further information	
Recommended reading	Mc Pherson M. J.: Mine Ventilation Handbook
Note	The assessment methods and the compulsory readings of this course will be announced in detail in the first lecture. The latest version of the lecture notes will be uploaded at the beginning of the semester.

Numerical Methods of Deposit Modeling

Course Nb	200.207
Credits	2,5
Type	Lecture / Practical
Offering period	Wintersemester
Lecturer	Oberndorfer
Course description	
Content	• Modeling theory • Data used for deposit modeling (geological mapping, sampling, etc.) • Data handling (database applications) • Concepts of interpretation and interpolation • Global estimates and descriptive statistics (property distribution, grouping, clustering) • Interpolation: qualitative and quantitative properties, principles and overview of methods • Linear Interpolation (triangulation): algorithms, assumptions, properties of generated surfaces, representation methods • Geostatistical methods: basic theory (linear combination, minimizing estimation error), algorithm, consequences • Statistical description of variability properties (covariances, variogram) • Point and volume estimates (size effect of sampling and estimation data) • Ordinary and indicator kriging • Aspects of integration into mining operation (methods, effort, realization, potential errors)

Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Basic knowledge of geology (deposit types and characteristics) and mining (interaction mining/deposit) • Basic knowledge of descriptive geometry • Basic knowledge of statistics • Skills/experiences with mine planning / deposit modeling software is advantageous but not mandatory
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to • Have a thorough understanding on modeling techniques • Understand reliability and accuracy of deposit modeling • Understand reasonable application of deposit models (global, regional, local estimates) • Understand cross-links and consequences on mine design, in particular quality control.
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lecture Active participation and discussion Focus is on theoretical background, but for illustration and better understanding some simple examples are presented and/or executed by the students (as far as possible, e.g. vacancy computer lab, basic skills of students in Surpac)

Further information	
Note	The assessment methods and the compulsory readings of this course will be announced in detail in the first lecture. The latest version of the lecture notes will be uploaded at the beginning of the semester.

Open Pit Mining

Course Nb	200.051
Credits	4,5
Type	Lecture
Lecturer	Häupl, Oberndorfer
Course description	
Content	• Overview on aspects affecting open pit mining • Mining situation Austria (design range, influencing factors) • Discussion on overall efficiency / effectivity (equipment/personnel/process) • Quality control (material classes), process transformation (extraction, loading/hauling, transport), forecast & surveillance, open pit design (geometry, equipment) • Truck haulage: loading & hauling, truck fleet, equipment aspects • Estimation & surveillance • Discussion of several examples (case studies): alternative evaluation, design aspects, decisive influencing factors • Operation monitoring, data management • Overview on a quarry operation from an economical and a technical point of view • Operation cycle of a typical quarry operation during a year's period • Factors of production: Material, utilities & energy, goods and services • Balance of cost and total revenue

	• Business processes: Drilling & Blasting, Loading & Hauling, Mineral-Processing, Mineral-Stock, Shipment onto the market • Organizational structure and main processes (leading and supporting processes / internal and external processes) • Process organization with a detailed view on the supply and value-chain • Discussion of an specific case study
Previous knowledge expected	• Good English skills • Basic knowledge on open pit mining and mining equipment • Basic knowledge on open pit mining business economics
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to • Have a knowledge about evaluation, design and operation of open pits (hard rock) • Have a knowledge about organizing, analyzing and administrating an open pit operation
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lecture Active participation and discussion Case study discussion has a prominent focus on interactive collaboration of the participants in teamwork

Further information	
Note	The assessment methods and the compulsory readings of this course will be announced in detail in the first lecture. The latest version of the lecture notes will be uploaded at the beginning of the semester.

Risk Management in Mines

Course Nb	200.145
Credits	1,5
Type	Lecture
Lecturer	Wagner
Course description	
Content	• Introduction into the objectives and methods of risk management in mines • Definitions: hazard, risk, damage, severity number, risk number • Types of risks in mining: safety, human, geological, technical, economic, contractual, political, time, environmental • Safety risk-safety statistics • Acceptable and tolerable risks • Methods of risk identification: brain storming, risk check lists, expert risk evaluation • Methods of risk analysis: Regression and correlation analysis, probabilistic event analysis, fault tree analysis, Delphi-method, Monte Carlo simulation, scenario building • Risk classification: risk matrix-severity and probability; risk register • Risk treatment: eliminate • Monitoring: physical, environmental, financial, human • Human factor in risk management

Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Proven knowledge of mining engineering (Bachelor in Mineral Resources Engineering, examination in major mining engineering subjects) • In case these are missing the student has to pass an entrance test at the beginning of the course with the following contents: o Surface and underground mining methods o Mining equipment o Mine ventilation o Geology
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to: • Have an appreciation of the inherent risks in mining • Have skills to identify and quantify mining risks • Know the risk management process with the emphasis on mining risks • Know risk analysis and evaluation techniques • Know about basic capabilities to perform risk assessment and management in mines.
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lectures Active participation and discussion
Examination	Oral examination
Further information	
Recommended reading	Hartman, h. L. and Mutmansky, J. M. (2002): Introductory Mining Engineering, John Wiley &Sons Inc., 570 pp.

	ISO 3100- Risk Management. Intern. Standards Organization Wagner, H. (2001): Die Besonderheiten des Risikomanagements im Bergbau. Berg- und Hüttenmännische Monatshefte, BHM., 146 Jg., Springerverlag Wien, S.37-41.
Note	The assessment methods and the compulsory readings of this course will be announced in detail in the first lecture. The latest version of the lecture notes will be uploaded at the beginning of the semester.

Underground Coal Mining

Course Nb	200.057
Credits	1,5
Type	Lecture
Lecturer	Bertginoll, Sifferlinger
Course description	
Content	Overview of major aspects of Underground Coal Mining: • World Coal Resources and Production • Prospecting and Exploration • Underground Mine Development • Underground Coal Mining Methods • Underground Coal Mine Operation and Machinery • Coal Preparation, Storage and Transport • Underground Coal Mining Investment and Cost • Underground Coal Mining Health and Safety • Environmental Impact of the Coal Industry • Examples of Underground Coal Mining Operations • Outlook and future developments
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Knowledge in Mining Engineering
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to • Understand underground coal mining operations • Know the methods of longwall and room & pillar mining, including roof control, ventilation, machinery, safety, infrastructure and transport.

	• Understand the cost and organization of an underground coal mine. • Know the health and safety in underground coal mining, including explosion protection, roof control, dust suppression, functional safety of equipment and personal protection.
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	• Lectures, multimedia-supported (e.g. Video-Clips) Power Point Presentation with further reference to special sources. • Active participation and discussion of examples. • Discussion of accident reports
Further information	
Recommended reading	• Bise, C. J., Modern American Coal Mining, Methods and Applications, Society for Mining, Metallurgy and Exploration, Englewood 2013
Note	The assessment methods and the compulsory readings of this course will be announced in detail in the first lecture. The latest version of the lecture notes will be uploaded at the beginning of the semester.

Underground Mining

Course Nb	200.036
Credits	4,5
Type	Lecture
Lecturer	Ladinig, Moser P.
Course description	
Content	• Underground mining methods. • Mine development. • Stoping methods for tabular deposits. • Rock Mechanic design of room and pillar system. • Pillar extraction mining. • Longwall mining. • Cut and fill mining methods. • Shrinkage stoping. • Open stoping. • Caving methods • Backfill
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Sustainable knowledge in the following fields - successful completion of the following lectures: o Mining Rock Mechanics (200.179) o Basics of Excavation Engineering (200.054)
Objective (expected results of study and acquired competences)	On completion of this course the participant should be able to -on the basis of a practical (deposit) example-: • Design the access to the deposit • Develop a mining method • Discuss the geotechnical requirements and implications of different mining methods

	• Join together and combine all his acquired knowledge (systems thinking)!!
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	• Lectures • Active participation and discussion.
Further information	
Recommended reading	• Brady, B.H.G. and Brown, E.T.: Rock mechanics for underground mining; 3rd Ed., 2004 • Cernica, J.; Soil Mechanics; 1995 • Hustrulid: Underground mining methods. 200 • Potvin, Y.; Thomas, E.: Handbook in Mine Fill; 2005
Note	The assessment methods and the compulsory readings of this course will be announced in detail in the first lecture. The latest version of the lecture notes will be uploaded at the beginning of the semester.

2. TU Bergakademie Freiberg

2. 1 Compulsory Subjects

Applied Engineering Geology and Brownfield Revitalisation

Course Nb	SUSBFR .MA.Nr. 090
Credits	6
Type	Lecture/Practical
Lecturer	Tamáskovics, Nándor
Course description	
Content	• The basis of Engineering Geology o Aims, Development o Materials and Mass Fabric o Environmental Factors • Investigating the ground o Geological materials, sediments, rock materials, fluids and gases o Description of materials, properties and their measurement o Geological masses o Maps o Recovery of samples o Field tests and measurements • Ground behaviour o Ground response to engineering and natural processes o Withdrawal of support by surface and underground excavations o Static loading of the ground o Dynamic loading of the ground o Ground reaction to changes of fluid and gas pressures

	• Technology of disposal sites and tailings o Geotechnical aspects related to the construction of disposal sites and tailings o site survey, investigations and characteristics o transport mechanisms of contaminants in the underground • Contaminated sites - investigation assessment and reusing (Lifecycle) o Environmental legislation relevant to contaminated sites o Quality control of sampling on contaminated sites, analytics of o site contaminations, reclamation process and monitoring o Assessment of water, soil and air pollution level (risk assessment) o Overview of reclamation methods and geotechnical securing measures o Safety of operation in dealing with contaminated sites o Aspects and concepts of site revitalisation (innercity areas/landscaping) • Cost-benefit considerations, case studies o Comparing various remediation strategies and selecting best option • Developing and assessing successful after-use scenarios o Risk assessment, marketing studies, cost benefit analysis

Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • B.Sc. in Geosciences or Geo-Engineering • Basic Knowledge of Geosystems
Objective (expected results of study and acquired competences)	On completion of this course the participant shall be able to: • Gain knowledge of the scientific field of engineering geology, including methods to evaluate soil and groundwater contaminated sites • Apply an interdisciplinary approach focusing on technique, economy, ecology and environmental law • Have the specific knowledge of a Brownfield Manager
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	The total time budgeted for the cluster is set at 180 hours (90 hours are spent in class and 90 hours are spent on self-study).
Further information	
Recommended reading	• Price, D.G.: Engineering Geology, Principles and Practice, Springer Verlag, Berlin-Heidelberg, 2009 • Franzius V.; Altenbockum M.; Gerhold T. (Herausgeber): Handbuch: Altlastensanierung und Flächenmanagement, Verlag C.F. MüllerTA Abfall/ Siedlungsabfall • Arbeitshilfen Altlasten • Sustainable Brownfield Regeneration: CABERNET Network Report • Proceedings ECI Conferences „Green Brownfields“

	• Document server: http://daemon.ifgt.tu-freiberg.de • Document server: http://penguin.ifgt.tu-freiberg.de
Note	The grade is generated from the examination result(s) with the following weights (w): MP/KA: Technology of disposal sites and tailings, Contaminated sites - investigation assessment and reusing [w: 2] AP: Project report: Cost-benefit considerations, Developing and assessing successful after-use scenarios [w: 1]

Mine Water: Hydrogeology and Modeling

Course Nb	MWGEOMO.MA.Nr.2089
Credits	6
Type	Lecture/Practical
Lecturer	Drebenstedt
Course description	
Content	• Basic of hydraulic subsurface flow in granular and fractured rocks. • Basic of transport of contaminants in seepage and groundwater, • Basic of water balance in particular in mining environments. • Analytical and numerical modeling. • Pros and cons of FD and FE models. • Setting up a 3d steady state flow and transport model, discretization, parameterization, defining boundary conditions, defining sinks and sources. • Manual and inverse calibration, sensivity analysis. • Special aspects of dewatering open pit and deep mines, groundwater recovery and mine flooding.
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Basic knowledge of physics, geology, and hydrogeology.
Objective (expected results of study and acquired competences)	On completion of this course the participant should be able to • Improve his knowledge on Hydrogeology and in particular in the field of groundwater flow and transport with special emphasis on mining

	and rehabilitation and remediation of mining related problems. • Understand basic and complex mining related groundwater problems • Evaluate numerical groundwater models
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	The workload is 180h. It is the result of 75h attendance and 105h self-studies. The latter comprises time for preparation and homework as well as preparation for exams.
Further information	
Recommended reading	• Domenico & Schwartz (1996): Physical and Chemical Hydrogeology, Wiley & Sons • Anderson & Woessner (1992): Applied Groundwater modeling - Simulation of flow and advective transport, Academic Press
Note	The grade is generated from the examination result(s) with the following weights (w): KA [w: 3] AP: Report related to the practials [w: 1]

Radioactivity

Course Nb	MWGEOMO. MA. Nr. 2089
Credits	6
Type	Lecture/Practical
Lecturer	Mischo, Weyer
Course description	
Content	• Radioactive decay • Special consideration of Rn222 and Radon decay, • Products • ICRP principles • Protection against radiation • Measurement and sampling, • Pathways • Risk analysis • Optimal remedial procedures • Decontamination techniques • Ventilation systems • Gases • Airway resistance
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Fundamentals in engineering and natural science
Objective (expected results of study and acquired competences)	On completion of this course the participant should be able to have a basic knowledge of • Radioactive decay • Measurement of radiation • Units • Technique of sampling • Decontaminations techniques
Languages of instruction	English

Teaching and learning method (delivery of skills) workload for students	Lectures (45h), seminars and practical training, excursions to rehabilitation sites (45h). The workload is 180h. It is the result of 90h attendance and 90h selfstudies. The latter includes industrial placement.
Further information	
Recommended reading	ICRP publications, especially ICRP 43 and 65, conference proceedings
Note	The Grade is generated from the examination result(s) with the following weights (w): MP/KA [w: 1] PVL: Project report [w: 0]

Reclamation

Course Nb	BBREKL .MA.Nr. 2087
ECTS	6
Type	Lecture/Practical
Lecturer	Drebenstedt
Course description	
Content	• Impacts of mining and its effects • Legal requirements for permission • Scientific fundamentals of reclamation (soil, ground water balance,…) • Concepts • Utilization requirements and realization in the post-mining landscaping (agriculture, forestry, waterbodies, nature protection, recreation, miscellaneous) • Case studies
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Fundamentals in mathematics and science
Objective (expected results of study and acquired competences)	On completion of this course the participant shall be able to • Understand the parallelism of mine and reclamation planning and the fact, why reclamation can exceed the mine project phase. • Explain scientifically reclamation measures • Plan technical measures • Calculate the financial expenses.
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lecture (45 h), exercise (30 h), practical training (15 h).

	Time effort is 180 h and consist of 90 h presence time and 90 h self-study (self-study includes autonomous and instructed preparation and performance of follow-up course work and examination preparation.
Further information	
Recommended reading	• Pflug (Hrsg.), 1998, Braunkohlentagebau und Rekultivierung, Springer Verlag • Olschowy, Bergbau und Landschaft, 1993, Paray Verlag • Gilscher, Bruns, 1999, Renaturierung von Abbaustellen, Verlag Eugen Ulmer Stuttgart
Note	Module grade is equivalent to the grade of oral module examination

2. 2 Restricted Electives

Biotechnology in Mining

Course Nb	BIOMIN .MA.Nr. 3043
Credits	4
Type	Lecture/Practical
Lecturer	Mühling, Schlömann
Course description	
Content	• Basics o Concepts of microbial energy metabolism o Chemolithotrophic growth o Diversity of electron acceptors o Microbial redox reactions with Sulphur, iron, manganese, arsenic, uranium. • Microbial leaching o Mechanisms of leaching o Microorganisms involved o Application of leaching for the production of copper, gold and diamonds, problem of mine waters. • Biotechnological treatment of mine waters o Microbial sulphate reduction for active treatment o Microbial iron oxidation o Wet lands. • Lab course o Special plating techniques for acidophilic bacteria o Anaerobic cultivation techniques o Measurement of parameters to follow growth of relevant microorganisms.

Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Master-degree applied science and geoecology or in another area of science or engineering.
Objective (expected results of study and acquired competences)	On completion of this course the participant shall be able to • Understand the parallelism of mine and reclamation planning and the fact, why reclamation can exceed the mine project phase. • Explain scientifically reclamation measures • Plan technical measures • Calculate the financial expenses.
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lecture (1 SWS), seminar (1 SWS), lab course (1 SWS), excursion (0,5 SWS) The workload is 120h. It is the result of 52.5h attendance and 67.5h selfstudies.
Further information	
Recommended reading	• Barton, L. L. & Hamilton, W. A.: Sulfate – Reducing bacteria Environmental and Engineered Systems, Cambridge University Press • Lovley, D. R. (Ed..): Environmental Microbe-Metal Interactions, ASM Press • Rawlings, D. E., & Johnson, D. B. (Ed..): Biomining, Springer • Reineke, W. & Schlömann, M. Umweltmikrobiologie, Spektrum Akademischer Verlag

Note	The Grade is generated from the examination result(s) with the following weights (w): KA [w: 1]

Deutsch A1/2. Semester

Course Nb	DEU A1/ 2. Sem. BA. Nr. 949
Credits	4
Type	Lecture/Practical
Lecturer	Bellmann, Paul
Course description	
Content	• Orientierung in der Stadt beziehungsweise in der Firma • öffentliche Verkehrsmittel • Wegbeschreibung • Berufe und Arbeitsalltag • Körper und Gesundheit • Wohnungssuche und –einrichtung • Lebenslauf • Kleidung • Grammatik o Präpositionen, Frageartikel, Modalverben, Possessivartikel, Perfekt, Konjunktionen, Demonstrativpronomen, Graduierung und Komparativ
Previous knowledge expected	Successful completion of the course Deutsch A1/1 or proof of equivalent proficiency in German.
Objective (expected results of study and acquired competences)	On completion of this course the participant should have a basic knowledge of • The German language • Listening, speaking, reading and writing skills in general language as well as regional and cultural studies
Languages of instruction	Deutsch

Teaching and learning method (delivery of skills) workload for students	Der Zeitaufwand beträgt 120h und setzt sich zusammen aus 60h Präsenzzeit und 60h Selbststudium.
Further information	
Recommended reading	• Begegnungen A1+, Schubert Verlag
Note	Die Note ergibt sich entsprechend der Gewichtung (w) aus folgenden(r) Prüfungsleistung(en): KA [w: 1]

Licensing, Stakeholder Involvement and Expectation Management

Course Nb	SUSLSE. MA. Nr. 088
Credits	6
Type	Lecture/Practical
Lecturer	Bongaerts, Jakubick
Course description	
Content	Expectations by the various stakeholders are identified as driving forces within a remediation project. The management of expectations of all involved stakeholders as well as transparent assessment and decision procedures are a core ingredient of this module, and will be discussed using case studies from a great variety of real-world projects and experiences. Students will be encouraged to contribute their personal and professional experiences to the module in order to both focus the content to the specific needs of the audience and to demonstrate the great cultural variety of negotiation and management styles.
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • No previous knowledge of management is required.
Objective (expected results of study and acquired competences)	Upon completion of industrial activity at a given site (e.g., mining, chemical production), liabilities must be investigated, assessed, and removed/remediated with respect to safe sage in the future. This is an iterative decision process involving many parties, often with conflicting interests and different ways to influence the outcome of this decision process. This module addresses the need to handle public inquiries, concerns, or conflicts on environmental and

	remediation issues. It shows environmental managers, regulators and public servants in this field, and consultants at industrial facilities how to identify the causes of environmental issues and concerns, create community relations programs to address issues or establish a proactive dialogue to prevent or minimize future environmental conflicts, and handle technical and risk communication in a highly efficient manner. The aspects which have to be observed within such a complex process include (but are not restricted to) • legal requirements, • economic conditions, • environmental objectives and regional political aims, communication, information management and negotiation methods. The subjects will be presented using overview texts and summary texts, graphs, and case studies. Discussions among students and between tutors and students will be facilitated by electronic means of communication such as email and a web-based discussion platform. Special emphasis will be laid on presentation of selected cases and discussion of critical parameters like timing cost, communication problems, information handling. Students will be trained in groups and individually. This module will also feature checklists, forms and worksheets as tools for further reference in the daily work.

Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	S1 (SS): Lectures (4 d), S1 (SS): Seminar (1 d) The workload is 180h. It is the result of 40h attendance and 140h self-studies.
Further information	
Recommended reading	• Leshy, J.D.: The Mining Law: A Study in Perpetual Motion, Resources for the Future, Routledge, ISBN: 0915707268, ISBN-13: 780915707263, 1987, 542 pp • Plunkett, W. R.,Attner, R. F., Allen, G. S.: Management: Meeting and Exceeding Customer Expectations, Thomson – South Western, 2005, ISBN 0324259131, 742 pp
Note	The Grade is generated from the examination result(s) with the following weights (w): KA [w: 1]

2. 3 Free electives

Human Resource Management and Organizational Behavior (HRMOB)

Course Nb	HRMOB. MA. Nr. 3203
Credits	5
Type	Lecture/Practical
Lecturer	Nippa
Course description	
Content	• Introduction • Organizational Behavior (OB) o Individual level (foundations of individual behavior; impacts of individual characteristics; impact of situational factors) o Group level (foundations of group behavior, understanding work teams; group processes e.g. communication, power, conflict) o Leadership • Human Resource Management (HRM) o Changing Nature of HRM o HRM Planning o Human Resource Adjustments o Training and Developing HR o Compensating HR • Presentations and Conclusions
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1)
Objective (expected results of study and acquired competences)	On completion of this course the participant shall be able to • Understand the relevance of human resources for organizations and the key concepts of human behavior in organizations.

	• Appreciate how the human side of management is an essential complement to the technical skills you are learning in other courses. • Learn concepts and approaches that will enable you to analyze HR and organizational problems and to develop appropriate solutions. • Develop the knowledge and skills you need to be a successful manager of yourself and others.
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lectures The workload is 90h. It is the result of 30h attendance and 60h self-studies.
Further information	
Recommended reading	Mathis, R.L.; Jackson, J.H.: „Human Resource Management“, 6th Ed. South Western College Publishing: Cincinnati 2006 Robbins, S.P.; Judge, T.A.: „Organizational Behavior“, 11th Ed. Pearson Prentice Hall: Upper Saddle River, N.J. 2007

International Development and Resources

Course Nb	IDEVRES. MA. Nr. 3417
Credits	6
Type	Lecture/Practical
Lecturer	Stephan
Course description	
Content	• Measuring Development • Theories of Economic Development • Development Policies: Approaches, Failures, and New Consensus? • The Role of Natural Resources for Economic Development and Welfare • Trade Policy in the Framework of Development Policy • Current Issues in Development Policy
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Knowledge at Bachelor level in business administration is required.
Objective (expected results of study and acquired competences)	On completion of this course the participant shall be able to • Understand the implications of management of firms in the environment of developing economies. • Understand that natural resources can easily turn into a curse, if they are not included into a coherent national development policy.
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lecture, exercises The workload is 180h. It is the result of 60h attendance and 120h self-studies.

Further information	
Recommended reading	Todaro, M. P. : Economic Development, 9th edition, Addison Wesley, New York, 2006 Various recent Journal articles from e.g. “World Development”, “World Bank Economic Review”; “Journal of Development Economics”. World Bank Development Report (current years)
Note	The Grade is generated from the examination result(s) with the following weights (w): KA [w: 4] AP: Presentation [w: 1]

International Resource and Environmental Economics and Management

Course Nb	IREEM. MA. Nr. 2082
Credits	6
Type	Lecture/Practical
Lecturer	Bongaerts
Course description	
Content	• Environmental management (EM) • Sustainability and environmental management (SEM) • Economics of Resources (ER)
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1)
Objective (expected results of study and acquired competences)	On completion of this course the participant shall be able to • Know about environmental management, in particular at the level of (industrial) organizations. Contemporary leading principles, such as sustainability, prudent handling of energy and resources will be introduced. • Apply the theoretical principles to practical problems of decision-making and management.
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lecture, exercises The workload is 180h. It is the result of 60h attendance and 120h self-studies.

Further information	
Recommended reading	A syllabus will be handed out to students at the beginning of the semester Reports by companies on environmental management and on sustainability Websites to be identified in the lectures Kolk, A. (2000) Economics of Environmental Management. Harlow, England: Financial Times Prentice Hall, Pearson Education.
Note	The grade is generated from the examination result(s) with the following weights (w): KA [w: 4], AP: Case studies (15 pages) [w: 1]

Introduction to Quaternary Geology

Course Nb	QUAGEO. MA. Nr. 3223
Credits	3
Type	Lecture/Field Trip
Lecturer	Breitkreuz
Course description	
Content	• Proxies for paleoclimatic variation in the last 2.5 Million years • Chronostratigraphic and other tools for stratigraphic correlation of the Quaternary • Important archives: lake- and marine sediments, ice cores • Glacial and periglacial processes and glacial sedimentology
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Principles of Geoscience (Secondary Subject) or equivalent modules.
Objective (expected results of study and acquired competences)	On completion of this course the participant shall be able to • understand the basic processes and techniques in the field of Quaternary Geology, and in particular in the field of paleoclimatic variation.
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lecture, field trip, practical application The workload is 90h. It is the result of 38h attendance and 52h self-studies. Self-studies include assignments, preparation and wrapping up of lectures as well as preparation of examinations.

Further information	
Recommended reading	Ehlers, J. (1995): Quaternary and glacial geology.- Wiley & Son, New York, 578S. Elias, S.A. (Ed.)(2007): Encyclopedia of Quaternary science.- Elsevier, 4 volumes, 3365 pp.
Note	The grade is generated from the examination result(s) with the following weights (w): KA [w: 1]

Meteorology, Climatology, Hydrology

Course Nb	METHYDR. BA. Nr. 182
Credits	6
Type	Lecture/Practical
Lecturer	Dunger, Matschullat, Zimmermann
Course description	
Content	• Atmospheric dynamics, radiation budget, global energy balance, meteorological parameters, global, regional, local climates and their dynamics, paleoclimatology, climate change. • Hydrological cycle and water budgets, precipitation formation, heavy rain and design depth of precipitation, snow accumulation and ablation, evapotranspiration determination and calculation, discharge formation, concentration and dynamics.
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Principles of Physics and Mathematics
Objective (expected results of study and acquired competences)	On completion of this course the participant shall be able to • Know the basics of Meteorology and Climatology as well as Hydrology • Understand the most important parameters and processes and to interpret related results. The links between the partial modules is a prerequisite for any application of models and the understanding of more complex and advanced tasks in Atmospheric and Climate Science and in Hydrology.

Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lecture, Alternating Met-Hydr / Exercises The workload is 180h. It is the result of 90h attendance and 90h self-studies. The latter comprises preparatory work and repetitions of the lectures and exercises and exam preparations.
Further information	
Recommended reading	Barry RG, Chorley RJ (2003) Atmosphere, weather and climate. 8th ed. Routledge Dyck S, Peschke G (1995) Grundlagen der Hydrologie. 3. Aufl. Verlag für Bauwesen, Berlin; Emeis S (2000) Meteorologie in Stichworten. Hirt Verlag; Hupfer P, Kuttler W (2005) Witterung und Klima. 11. Aufl. Teubner Verlag; Kraus H (2004) Die Atmosphäre der Erde. 3. Aufl. Springer Verlag; Maidment, DR (1992) Handbook of Hydrology. McGraw-Hill; Maniak U (2005) Hydrologie und Wasserwirtschaft. Eine Einführung für Ingenieure. 5. Aufl. Springer‑Verlag; Schönwiese CD (2008) Klimatologie. 3. Aufl. Ulmer Verlag; Zmarsly E, Kuttler W, Pethe H (2007) Meteorologisch-klimatologisches Grundwissen. Eine Einführung mit Übungen, Aufgaben und Lösungen. 3. Aufl. Ulmer Verlag
Note	The Grade is generated from the examination result(s) with the following weights (w): KA [w: 1]

Organizational Communication

Course Nb	ORGCOMM. MA. Nr. 3366
Credits	6
Type	Lecture/Practical
Lecturer	Hinner
Course description	
Content	• Organizational communication theory, social components of communication, social networks, diversity and communication, identity, corporate culture and communication, power and communication, negotiation, attitudes, and persuasion, conflict communication, internal and external communication, formal and informal communication, stakeholder communication, crisis communication, globalization, technology and communication. • The tutorial integrates the above topics into an applied context (e.g. the resource industry, engineering, etc.). Participants will analyze and discuss the topics and contexts in small groups and present the results informally and formally throughout the semester.
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1)
Objective (expected results of study and acquired competences)	The module seeks to transmit the theoretical foundation for organizational communication and apply it in a real world context to see how effective internal and external communication can transmit competence, credibility, and ethics to all essential stakeholders within and without organizations as well as the public at large.

Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lectures, exercises. The workload is 180h. It is the result of 60h attendance and 120h self-studies. Self-study time includes reading the relevant literature, preparation and follow-up work for in-class participation as well as preparation time for the written exam, i.e. “Klausurarbeit” and the assignments.
Further information	
Recommended reading	The script is sold at the beginning of the semester. Conrad, C., & Poole, M.S. (2002). Strategic organizational communication Fort Worth: Harcourt. Hinner, M.B., Ed. (2007, 2010). Freiberger Beiträge zur interkulturellen und Wirtschaftskommunikation, Volume 3 and 6. Frankfurt am Main: Peter Lang. Keyton, J. (2005). Communication and organizational culture: A key to understanding work experiences. Thousand Oaks: Sage. May, S., & Mumby, D.K. (2005). Engaging organizational communication theory and research. Thousand Oaks: Sage.

Note	The Grade is generated from the examination result(s) with the following weights (w): KA* [w: 4], AP*: Active Written and Oral Participation, Presentations, and Assignments in the Course [w: 1] * In Modules with more than one exam, this exams has to be pass successfully respectively has to have a result at least "ausreichend" (4,0).

Sustainability Management

Course Nb	SUSTMAN. MA. Nr. 2908
Credits	6
Type	Lecture/Practical
Lecturer	Bongaerts, Gurita
Course description	
Content	• The concept of sustainability • Conceptual and theoretical foundations of sustainability (part I and II) • Sustainability indicators and Reporting Frameworks • Life Cycle Assessment - Concept Overview - • Introduction to Sustainable Banking and Sustainable Asset Management • Global Trends in Sustainability
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1)
Objective (expected results of study and acquired competences)	On completion of this course the participant shall be able to • Be familiar with the concept of sustainability, its scope and the interrelation between the economic, social and ecological dimensions • Critically assess situations and make appropriate decisions as well as develop further their personal communication skills while working in teams and participating in lecture activities.
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lectures, exercises. The workload is 90h. It is the result of 30h attendance and 60h selfstudies.

Further information	
Recommended reading	Robert L. (2008), Environmental issues: an introduction to sustainability, McConnell Clayton, Anthony M.H. (1996), Sustainability: a systems approach, Burian, Martin (2006), The clean development mechanism, sustainable development and its assessment, Labatt S. & White R.R. (2007), Carbon Finance – The Financial Implications of Climate Change
Note	The Grade is generated from the examination result(s) with the following weights (w): AP: term paper [w: 7] AP: paper presentation [w: 3]

3. National Technical University Dnipro Polytechnic

3. 1 Compulsory Subjects

Geomechanics

Course Nb	
Credits	6
Type	Lecture/Practical
Lecturer	Babets, Sdvyzhkova
Course description	
Content	• Basics of continuum mechanics • Strength theories and failure criterions • Post-failure behavior of rocks • Numerical simulation of rock stress-strain state • Support loading • Opening stability • Safe factor and probability of failure • Geomechanical processes at longwall mining • Mining rate effect • Dynamic manifestations of rock pressure • Methods of observation in situ • Rock mass properties and • Probability estimation of scale effect.
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Mathematic-scientific fundamentals, geology, basics of elasticity theory

Objective **(expected results of study and acquired competences)**	The module provides the development of expertise and methodological skills in the field of rock mechanics. On completion of this course the participant shall be able to • Know the theory and practical rock engineering • Estimate the geomechanical situation and predict the behavior of rock mass in different geological terms • Simulate the rock stress-strain state • Determine support parameters providing the effective mining and safety. • Carry out geomechanical monitoring to forecast the rock pressure manifestations.
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lecture 45h, exercises (30 h), practical training (15h) Time effort is 180 hours and consist of 90 h presence time and 90 h self-study (self-study includes autonomous and instructed preparation, home work and preparation for exams).
Further information	
Recommended reading	Rock mechanic (Novy druc, 2003) Rock Mechanics: For Underground Mining (Springer, 2004) Practical rock engineering (Balkema, 2007)
Note	The grade for this module is the average grade of the written exam and 2 home works.

Legal Issues of Environment

Course Nb	
Credits	2,5
Type	Lecture/Practical
Lecturer	Grischak, Shashenko
Course description	
Content	• Analysis and characteristics of the EU environmental policy influence to the legal issues of the mining industry. • Targets, principles and requirements of environmental law. • Legal protection. • Access to information, public participation in decision-making and access to justice in environmental matters. • Conformance inspection and environmental liability. • Environmental protective power. • Industrial objects. • Transportation gas emissions. • Ozone protection and climate change. • Water protection. • Integrated waste management. • Regulation of production circulation. • EU in International Environmental Law and Policy..
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Basic knowledge on mineral and their using in society, environmental law, legal issues of the mining industry.

Objective (expected results of study and acquired competences)	On completion of this course the participant shall be able to • improve their basic knowledge with respect to issues of the environmental law in mining in EU, Ukraine, Russian Federation.
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	12 weeks course with exercises (lecture 20h, practical training 10h). Work load is 75 hours, comprising 30 hours course time and 45 hours working at home. The latter comprises time for preparation and home work as well as preparation for exams.
Further information	
Recommended reading	Dhondt Nele. Integration of Environmental Protection into other EC Policies. Legal Theory and Practice. Groeningen; Europa Law Publishing, 2003. Hedemann-Robinson Martin. Enforcement of European Union Environmental Law:
Note	The grade for his module is taken from non weighted average of the written exams and the one report.

Mineral Processing

Course Nb	
Credits	6
Type	Lecture/Practical
Lecturer	All involved lectures of the master course Ore Concentration and Technologies of Mineral Processing,
Course description	
Content	• Analysis of literature and science works; testing geological equipment and methods for technological estimate of minerals • Realization of calculations and numerical simulations • Scientific analysis and generalization of the results (period of the months). • Preparation of scientific work and paper in a colloquium (30 min oral presentation with discussion).
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Proof of the successful conclusion of mandatory and optional modules (see study and examination regulations).
Objective (expected results of study and acquired competences)	On completion of this course the participant shall be able to • Solve scientific tasks in the field of advanced mineral processing • Prepare a scientific presentation of its work and defend it in front of an audience.(Ecological aspects also have to be considered in the work.)

	• The master thesis is a kind of examination which completes the entire course. The work is the proof, that the students are able to solve scientific problems by their own.
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lecture 45h, exercises (30 h), practical training (15h) Time effort is 180 hours and consist of 90 h presence time and 90 h self-study (self-study includes autonomous and instructed preparation, home work and preparation for exams).
Further information	
Recommended reading	Guideline for the preparation of scientific works at TU Bergakademie Freiberg from 27.06.2005, DIN 1422, part 4 (08/1985)
Note	The overall grade for the cluster is a computed of the grade for thesis (weighting 2) and the grade for colloquium (weighting 1).

Modern Geotechnology of Open-Cast Mining

Course Nb	
Credits	3
Type	Lecture/Practical
Lecturer	Cherep, Lozhnikov
Course description	
Content	• Study of modern approaches to the selection of the rational development systems and mining and transport equipment in open cast mining • Complex development of open casts and the principles of technogenic deposits' formation • Classification of technogenic formations according to purpose • Systematization of conditions • Choice of effective technology of technogenic deposits' forming and their further mining.
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Basic knowledge on mineral and their using in society, mineral prospecting and exploring, evaluation of deposits.
Objective (expected results of study and acquired competences)	On completion of this course the participant shall be able to • Solve scientific problems related to rational and complex deposit development of open cast mining • Analyze and substantiate the selection of development system and mining and transport equipment • Systematize conditions according to which

	technogenic deposits are formed and determine the technology of their formation
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	16 weeks course with exercises (lecture 32h, practical training 20h). Work load is 90 hours, comprising 52 hours course time and 38 hours working at home. The latter comprises time for preparation and home work as well as preparation for exams.
Further information	
Recommended reading	Ekologiya girnychogo vyrobnytstva / Baka M., Gumenik I., Redchits. - 2004. (ukr) Formuvannya ta rozrobka takhnogennykh rodovysch / Gumenik I., Semeniy P. - 2012. (ukr) Klassifikatsiya tehnogennykh formirovaniy pri otkrytykh gornykh rabotakh / Gumenik I. // Gorny jurnal. - 1988. - №12. - S. 53-56. (rus) Nauchnye osnovy ratsional'nogo prirodopol'zovaniya pri otkrytoi razrabotke mestorojdeniy: monografiya / Pivniak G., Gumenik I., Drebenstedt C., Panasenko A. - 2011. (Rus)
Note	The grade for his module is taken from non weighted average of the written exams and the two reports.

Modern Geotechnology of Underground Mining

Course Nb	
Credits	3
Type	Lecture/Practical
Lecturer	Dychkovs'kiy, Kovalevs'ka
Course description	
Content	• Knowledge of new mining methods of mineral deposits extraction together with new methods of roof management during high rater of the longwall advance. • Mathematical simulation of the support functioning in development mine workings, study stress-strain state of the rock massif and development of new bolt support designs. • Unmanned mineral extraction technologies development using electro-hydraulic management systems of machinery. • Plough systems are examined for coal extraction from thin and very thin seams. • Analytical models describing geomechanical interaction "massif – support" system elements. • Knowledge about boreholes underground gasification technology. • Research of gas hydrates and development of technologies for their extraction scrutinized.

Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Basic knowledge on mineral and their using in society, mineral prospecting and exploring, evaluation of deposits.
Objective (expected results of study and acquired competences)	On completion of this course the participant shall be able to • Improve their basic knowledge with respect to new progressive technologies in underground mining, management of strain and stress state of the massif substantiation of rational parameters of various types of support and others.
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	4 weeks course with exercises (lecture 35h, practical training 10h). Work load is 90 hours, comprising 45 hours course time and 45 hours working at home. The latter comprises time for preparation and home work as well as preparation for exams.
Further information	
Recommended reading	Methods of calculation displacement and strengthening of edge rock mining excavations (Lizunov Pres, 2010 Rus). New techniques and technologies in mining (Balkema, 2010) Technical and Geoinformational Systems in Mining (Balkema, 2011) Technology of underground mining of sheeted mineral deposits (Poligrafist,2003 Rus) Development of scientific bases of lifting the stability of mine excavations (Lizunov Pres, 2010 Rus)

Note	The grade for his module is taken from non weighted average of the written exams and the two reports.

Technical and Economic Assessment of Mining and Post Mining

Course Nb	
Credits	6
Type	Lecture/Practical
Lecturer	Bardas
Course description	
Content	• Pros and cons of mining on new territories. • Evaluation of potential losses and incomes of mining project realization. • Calculation of mining project costs. • Choice of mining technique on mineral deposit's design stage. • Economic assessment of managerial decisions during the pit closure stage. • Elimination of mining enterprises and their transformation in ecologically sustainable systems.
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Basic knowledge of environmental economics.
Objective (expected results of study and acquired competences)	On completion of this course the participant shall be able to • Improve their knowledge of economic assessment of mining and post mining with respect to reclamation of post mining territory, utilization of mine water, usage of mine workings and extracted rocks during the exploitation period of coal mines and after it.
Languages of instruction	English

Teaching and learning method (delivery of skills) workload for students	16 weeks course with exercises (lecture 40h, practical training 40h) Workload is 180 hours, comprising 80 hours course time and 100 hours working at home. The latter comprises time for preparation and homework as well as preparation for exams.
Further information	
Recommended reading	Adler, Claassen, Godfrey, and Turton, Water, mining, waste: South Africa p. 33 – Vol. 2, No. 2 (2007) Bosson, R., Varon, B. Mining industry and the developing countries. [excludes fuel sources and construction materials], Oxford University Press,New York, 2008, 304 Rebecca A. Adler, Marius Claassen, Linda Godfrey, and Anthony R. Turton, Water, mining, and waste: an historical and economic perspective on conflict management in South Africa, The Economics of Peace and Security Journal, ISSN 1749-852X Sweigard, R.J. , Ramani, R.V. A regional comparison of postmining land use practices (1983)
Note	The grade for this module is taken from non-weighted average of the written exam, report and two essays

Underground Construction

Course Nb	
Credits	3
Type	Lecture/Practical
Lecturer	Kovalenko, Shashenko, Solodyankin
Course description	
Content	• Peculiarities of interaction between society and nature at the present stage. • Current status and problems of development of underground space. • Interaction of an underground facility with the surrounding natural environment. • Re-use of underground facilities and waste mine workings. • Use of underground space of cities. • Underground structures of the transport destination. • Underground facilities for public use. • Industrial underground structures. • Buildings for Energy industry. • Underground storage tanks. • Facilities for special purposes. • Integrated use of underground space.
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Basic knowledge of geomechanics and construction technology of underground workings.

Objective **(expected results of study and acquired competences)**	On completion of this course the participant shall be able to • Know the comprehensive utilization of underground space, technologies of construction of underground facilities by open, underground and special methods of construction, the work organization, and the environmental aspects of underground construction. • Take reasonable method of construction of the object, technology and equipment for construction of the object, to determine the basic parameters of the organization of work.
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lectures (22 hours), practical training (12 hours) Work load for the course is 90 hours, of which 34 hours are spent in the class, 4 hours are devoted to consultations, 2 hours are spent on exam and 50 hours of are spent on self-study.
Further information	
Recommended reading	Hall, L.: Underground Buildings: More Than Meets the Eye, Quill Driver Books, 2004 Lysikov, B., L. Kaufmann, L.: Underground structures, Nord-Press, Donetsk, 2005 Sinha, R.S. (Ed.): Underground Structures: Design and Construction. Elsevier Science, 1991 Sterling, R., Carmody, J.: Underground Space Design, Wiley & Sons Ltd, 1993

Note	The grade for this module is taken from weighted average of the written exams and report proportionally to the hours spent on lectures and practical training.

4. China University of Mining and Technology Beijing

4. 1 Compulsory Subjects

Longwall Mining

Course Nb	CUMTB011MAOB1
Credits	6
Type	Lecture/Site visit
Lecturer	Weidong Pan
Course description	
Content	• Overview of Longwall Mining • Longwall Mining Trends. • Longwall Mining Process • Design, Management and Parameters of Longwall Mining • Alignment Longwall Mining Method • Incline Longwall Mining Method • Slicing Longwall Mining Technology • Longwall Top-coal Caving Technology • Heavy Pitch Longwall Mining Technology • Final Comprehensive Design Project
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Basic knowledge on stress and strain • Basic knowledge on coal mine geology
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to have • necessary knowledge, skills, tools and ability to design a complete longwall mining system and primary means of extracting coal. • overall design of longwall system as well as the individual design of the various sub-systems and their interrelation to other mine

	systems. • the responsibility of a working mining engineer.
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Method of Teaching: lecture + site visit + Written or oral exam (90 minutes) and one homework Workload: The total time budgeted for the cluster is set at 180 h (60 academic hours are spent in class, 30 hours are spent in site visit and 90 hours are spent on self-study).
Further information	
Recommended reading	Syd S. Peng. Longwall Mining(2nd Edition). New York : Wiley, 2006 W.D. Pan. English for Coal Mining Engineering. Beijing: Coal Industry Press, 2014, P49
Note	

Mineral Processing

Course Nb	CUMTB011MAOB3
Credits	5
Type	Lecture + site visit
Lecturer	Weiwei Xie
Course description	
Content	• Introduction of Mineral Processing • Crushing • Grinding • Screening and Classification • Gravity Separation • Magnetic Separation and Electrical Separation • Forth Floatation • Ore Sorting • Dewatering • Tailing Disposal • Processing and Applications of Coal Bearing Kaolinite, Gangue, and Flyash • Mineral Processing Plant Design
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Basic knowledge on physics and chemistry
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to have • necessary knowledge, skills, tools and ability to design a simple mineral processing plant. • the pre-prepare method of separation. • physical separation method according to the difference of gravity or surface properties, dewatering and tailing disposal, and the overall introduction of the coal bearing non-metallic minerals or tailings as well as their

	individual processing and applications. • procedures for a mineral dressing plant design • the responsibility of the mineral processing engineer.
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lecture, site visit, written exam (80%) and one mini-design report (20%) The total time budgeted for the cluster is 180 h (50 academic hours are spent in class, 30 hours are spent in site visit and 100 hours are spent on self-study).
Further information	
Recommended reading	B. A. WILLS, Mineral processing technology. British, 1981.
Note	

Rock Mechanics for Underground Mining

Course Nb	CUMTB011MAOB2
Credits	6
Type	Lecture / Site visit
Lecturer	Yixin Zhao
Course description	
Content	• Rock mechanics and mining engineering • Rock mass structure • Rock strength and deformability • Pre-mining state of stress • Excavation design in stratified rock • Excavation design in jointed rock • Mine stability and rockbursts /coal bumps • Rock deformation in deep mining • Monitoring rock mass performance • Advanced simulation methods for mine design • Ground control
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Basic knowledge on stress and strain
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to have • the basic principles in rock mechanics including: stress analysis, geology, discontinuities, rock mass classification, etc. • the application of the rock mechanics principles for the overall analysis and design of various ground control sub-systems including: entry widths, pillars, roof bolts, supplemental support, slopes, etc.

	• numerous practical applications of mathematics, mechanics and engineering to solve problems and design sub-systems related to ground control.
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lecture, site visit, written or oral exam (90 minutes) and one homework The total time budget for the course is 180 h (60 academic hours are spent in class, 30 hours are spent in site visit and 90 hours are spent on self-study).
Further information	
Recommended reading	Brady, B. H. G., Brown, E. T.: Rock Mechanics For Underground Mining, Kluwer Academic Publishers, 2004 Hudson, J.A., Harrison, J. P.: Engineering rock mechanics, Elsevier Science Ltd., 1997 Peng, S. S., 2008, Coal Mine Ground Control, 3rd edition, Morgantown, WV, 750 p
Note	

Safety Engineering in Mine

Course Nb	CUMTB011MAOB4
Credits	5
Type	Lecture + site visit
Lecturer	Kai Wang, Baisheng Nie, Dr. Aitao Zhou, et al.
Course description	
Content	• Aim of Safety Engineering in Mine • Mine ventilation o Introduction to fluid dynamics related to mine ventilation o Fans and auxiliary affiliations o Coal Mine ventilation system o Coal mine ventilation network analysis o Coal mine ventilation planning and practice • Mine gas control o Basic knowledge of mine gas o Gas explosion o Coal and gas outburst o Gas drainage • Mine airborne dust control • Mine fire control
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Basic knowledge on fluid flow and underground mining.

Objective **(expected results of study and acquired competences)**	On completion of this course the participants shall be able to have • key aspects of safety engineering in underground coal mines, including the design of ventilation system, basic knowledge and novel technology of the control of mine gas, mine dust and mine fire.
Languages of instruction	English
Teaching and learning method (delivery of skills) **workload for students**	Lecture, site visit, written or oral exam (90 minutes) and one homework The total time budget for the module is 150 h (50 academic hours are spent in class, 25 hours are spent in site visit and 75 hours are spent on self-study).
Further information	
Recommended reading	McPherson, M. J. :Subsurface Ventilation Engineering, ISBN-13: 978-0412353000
Note	

4. 2 Restricted Electives

Case Study on Mining Safety

Course Nb	CUMTB011MAEL2
Credits	5
Type	Lecture / Laboratory
Lecturer	Chengwu Li, Baisheng Nie, Xiangchun Li, Jing Li, Beijing Xie
Course description	
Content	• Gas poisoning, suffocation accident case analysis • Coal and gas outburst accident case analysis • Gas explosion accident case analysis • Coal spontaneous combustion disaster case analysis • External-caused fire accident case analysis • Internal-caused fire accident case analysis • Pneumoconiosis disaster case analysis • Coal-dust explosion accident case analysis • Ground flood accident case analysis • Underground flood accident case analysis
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Basic knowledge on Coal Mining Science, Mine Ventilation and safety, Coalfield geology, Mine pressure and roof control
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to have • professional knowledge of disaster prediction and prevention during the process of coal mine production. • analyzing the causes, influencing factors and preventive actions of methane, fire, dust and

	the representative technology gaps through lots of typical accidents cases • the mechanism of typical accidents, measures and actions of preventions and some relevant knowledge of management issues from the case analysis • responsibility of a working mining engineer
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lecture, seminar, lab, written or oral exam (90 minutes) and one homework The total time budget for the module is 100 h (50 hours are spent in class; 50 hours are spent on self-study).
Further information	
Recommended reading	He, X: Theory and Technology for the Prevention of Coal Mine Disasters, Xuzhou: CUMTP, 2006 Wang, J., Li, W.: Chinese coal mine accidents and expert comments set, Beijing: CCIPH, 2002 Yu, B.: Coal mine gas control and utilization of technical manual disaster, Beijing: CCIPH, 2005
Note	

Coal Fire Control

Course Nb	CUMTB011MAEL5
Credits	5
Type	Lecture / Site visit
Lecturer	Hongqing Zhu
Course description	
Content	• Overview of the state of coal fires in the world and in China • Overview of coal fire induced hazards such as the loss of valuable coal resources, emission of green-house gases (CO2 and CH4), emission of toxic gases (CO, H2S, NOx, etc.) and trace elements (F, As, Hg, etc.), subsidence, slide slope, etc. • Susceptibility of coal to self-ignition and chemical reactions of coal oxidation and combustion • Development and propagation of coal fires, crack formation, related ventilation path, and other factors impacting coal fires such as wind, solar heating, precipitation, and mining • Overview of techniques controlling coal fires and their own advantages and disadvantages • Three-phase foam. This part include introduction of gas, liquid and solid materials; functions of each materials; optimized mass ratios of materials; process of producing three-phase foam; equipment system of producing three-phase foam; the method to calculate the required amount of three-phase foam quenching a coal fire

	• Grout injection. This part is consisted of the following contents: composition of grout; optimized mass ratios of composed ingredients of grout; effective grouting area and its impacted factors; diameter requirement of solid particles; flow resistance of grout in pipes; grouting system utilized in in-situ coal fires; the method to calculate the required amount of grout extinguishing a coal fire • Gel injection. This part contains: introduction to various gel; chemical composition of each gel; cost, advantages and disadvantages of each gel; effective grouting area and its impacted factors; flow characteristics of gel transportation in pipes; designed equipment for gel injection; the method to calculate the required amount of gel extinguishing a coal fire • Introduction of other approaches such as water injection, heat pipes, loess coverage and reclamation • Application to these techniques for control coal mine fires, waste pile fires and smoldering fires
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Basic knowledge on fire safety, combustion and physicochemical properties of coal.
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to understand • how coal fires develop • how to control coal fires in order to protect valuable resources, environment, and human health.

	• techniques of controlling coal fires in order to control coal mine fires, waste pile fires, and other smoldering fires.
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lecture, site visit, written or oral exam (90 minutes) and one homework The total time budget for the module is 180 h (50 academic hours are spent in class, 30 hours are spent in site visit and 100 hours are spent on self-study).
Further information	
Recommended reading	Coal and peat fires-A global perspective (volume 1). New York : Elsevier, 2011. P381 Theory and techniques of gel extinguishing coal seam fires (in Chinese). Beijing: Coal Industry Press, 2003. P319 Theory and techniques of three-phase foam controlling spontaneous combustion of coal (in Chinese). Xuzhou: China University of Mining and Technology Press, 2009. P171
Note	

Coal Mine Backfilling Techniques

Course Nb	CUMTB011MAEL3
Credits	5
Type	Lecture / Field trip
Lecturer	Di Wu
Course description	
Content	• Basic Concept and Terminology for Coal Mine Backfilling • Developing trend of Coal Mine Backfilling • Methods and Technology for Coal Mine Backfilling • Selection and Optimization of the Backfill Materials • Rheological Characteristics of the Backfill Slurries • Transportation of the Backfill Materials • Coal Mine Backfilling System • Ground Control Mechanism of the Coal Mine Backfills • Backfilling Costs and Other Considerations
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Basic knowledge on Elastic-plastic Mechanics, Rock Mechanics and Fluid Mechanics
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to have • basic theory and technology of coal mine backfilling. • an introduction of the developing trend of coal mine backfilling, • the rheological and transportation properties of coal mine backfill slurries, as well as the

	ground control mechanism of the backfills. • the craft and technology of coal mine backfilling • the understanding of the significance of coal mine backfilling to the environment • design of a coal mine backfilling system and conduct research on coal mine backfilling.
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lecture, site visit, written or oral exam (90 minutes) and one homework The total time budget for the module is 180 h (50 academic hours are spent in class, 30 hours are spent in site visit and 100 hours are spent on self-study).
Further information	
Recommended reading	Antonov, D.: Mine Backfill Design and Characteristics: New Concept for Backfill Underground Support, 2009 Granholm, S. (Editor): Mining with Backfill Hardcover, 1983 Potvin, Y., Thomas, E., Fourie, A.: Handbook on Mine Fill, 2005
Note	

Engineering CAD

Course Nb	CUMTB011MAEL1
ECTS	5
Type	Lecture / Laboratory
Lecturer	Yang Li
Course description	
Content	Part I. Fundamental of AutoCAD: • Introduction and starting creating simple drawing and plotting • Control draft settings • A system of layers • Using more construct commands • Annotating and modifying drawings • Block and wblock references and process flowsheet Design • Dimensioning drawings • Creating geometric figures and advanced modified commands • Hatching and boundaries Part II. Mine Surveying Data analysis and Applications: • Mine surveying data analysis using spreadsheet templates • Applications of SurvCAD/AutoCAD: o Mine surveying mapping o Mine surface contours/elevation topographic mappings o Cut/fills volume calculation o Underground mine mapping o File Management

	• Organizing and management of files, mine mapping project report writing-up, and presentation slide creation (if time allowed)
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Basic knowledge on mining engineering and coal mine geology.
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to have • necessary knowledge of engineering CAD concepts and techniques, implementing applications of engineering computer aided design for engineering graphics and plant design, introduction of geometry and calculation of engineering works
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Attendance (15%), AutoCAD homework (30%), class exercise (15%) and final report (40%). The total time budget for the module is 50 h (38 academic hours are spent in class, 12 hours are spent in computer lab and 10 hours are spent on self-study).
Further information	
Recommended reading	Peng, F. F., Civil Suite (SurvCADD) integrated with AutoCAD manual, Surveying Data Analysis using spreadsheet templates Notes, Mining Engineering Department, WVU, Morgantown, WV, 2014. Stellman, T. A., Krishnan, G. V.: Harnessing AutoCAD: 2013 and Beyond, Autodesk Press, Albany, NY
Note	

Pit Mining and Environment

Course Nb	CUMTB011MAEL4
Credits	5
Type	Lecture / Site visit
Lecturer	Chunlai Wang
Course description	
Content	• Basic Concept of Open Pit Mining • Process of Open Pit Mining • Determination of the Mining Limit of an Open Pit Mine • Open Pit Development • Production capability • Schedule of Extraction and Development • Waterproof and Drainage • The risk of progressive failure of pit slopes • Reclamation and Environment Rehabilitation • Design work of an Open Pit Mine
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Basic knowledge on blasting engineering, rock mechanics and mining machinery.
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to have • basic concept and terminology in open pit mining. • the procedure and technology for developing an open pit mine. • the design principle, design approach and management technology of open pit mining • the knowledge of surface mining equipment and the environment-related problems induced by open pit mining

	• the ability to plan, design, construct, manage an open pit mine, as well as how to conduct research on surface mining.
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Problem-based learning lecture, site visit , written or oral exam (90 minutes) and one homework The total time budget for the module is 180 h (50 academic hours are spent in class, 30 hours are spent in site visit and 90 hours are spent on self-study).
Further information	
Recommended reading	Hustrulidand, W. A., Kuchta, M.: Open Pit Mine Planning and Design, 2006 Kennedy, B. A.: Surface Mining, 1990
Note	

5. Amirkabir University of Technology Tehran

5. 1 Compulsory Subjects

Advanced Engineering Mathematics

Course Nb	
Credits	3
Type	Lecture
Lecturer	Dr Hamed Molladavoodi
Course description	
Content	Tensor &Vector Calculus;Index Notation Tensors algebra operation;Vector Calculus Fourier series; oven and odd fourier series oven and odd fourier series;derivation from fourier series;Fourier integral and convention;partial differential equations;wave equation;thermal equation Laplacian equations;complex variables;analytical functions;continuity of complex function;complex integrals; engineering applications
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Engineering mathematics
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to Understand advanced engineering mathematics and its use in rock mechanics
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Theoretical Lecture
Further information	
Recommended reading	

Advanced Rock Mechanics

Course Nb	
Credits	2
Type	Lecture
Lecturer	Dr H. Salari Rad / Dr H. Molladavoodi
Course description	
Content	• Introduction- Rock and rock materials: physical properties and mechanical behavior of rock, • Rock strength: uniaxial and three-axial strength, tension and bending resistance of fractured rocks, effect of anisotropy on rock's strength, • Yielding criterion of rocks: elastic and brittle failure criterion, plastic failure criterion • Laboratory tests in rock's behavior study: static and dynamic tests, size effect and stress gradient on rock's behavior, Instrumentation in rock mechanics, • In-situ techniques for rock's behavior study: shear strength test, In-situ stress and deformation measurement techniques, • Rock mechanics application in design of the tunnels, rock slopes and rock foundation, rock mass improvement strength methods.

Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • The course is planned for the Rock Mechanics MSc. students with mining, civil or geology engineering BSc. formation.
Course Objective: **(expected results of study** **and acquired competences)**	On completion of this course the participants shall be able to: • Evaluate the stability of rock structures such as tunnels, caverns, slopes and other underground structures, and to analyze and solve an unstable condition in these structures. • Design of tunneling, mining layout and rock support.
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lecture
Further information	
Recommended reading	Brady BHG, Brown ET. Rock mechanics: for underground mining, UK: Chapman & Hall; 1999 Hoek & Brown, Underground Excavations in Rock, 1980 Goodman, R.E., Introduction to Rock Mechanics, 2nd Ed. 1989 Obert & Duvall, Rock Mechanics and the Design of Structures in Rock, 1967. Pariseau, William G., Design Analysis in Rock Mechanics

	J.C. Jaeger, N.G.W. Cook, R. Zimmerman, Fundamentals of Rock Mechanics (Fourth Edition). (2007) Blackwell
Course goal achievement measures:	4 assignments (20%), 1 Seminar (15%), 2.5-hr final exam (45%), Course project (20%)

Continuum and Discontinuum Mechanics in Rocks

Course Nb	
Credits	3
Type	Lecture
Lecturer	Dr Hossein Salari Rad
Course description	
Content	• Introduction and assumption in continuum rock media, • Stress, stress tensor, deviatoric stress, equilibrium equations, stress projection on a plane, sum and subtraction of stress, Maximum shear stress, Octahedral stress, • Strain, Deformations, Lagrangian and Eulerian deformation description, Small limited strains, Compatibilities' equations, • Linear and non-linear elastic stress-strain relationship, • Solid stress relationships, Stress equilibrium equations, Stress compatibilities' equations, Elasticity equations in special conditions, • Plasticity, Introduction on physical plastic behavior of materials, • Yield stress surface equation for Tresca, Von Mises, Mohr-Coulomb and Drucker Prager, Flow rule, Plastic potential, • Fracturing, Flow rule in discontinue media, Constitutive laws in discontinue media • fracture mechanics(LEFM basic), • Mechanical behavior of single fracture and models • Water flow in discontinue media

	• Homogenization and equivalent properties in fractured media
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • The course is planned for the Rock Mechanics MSc. students with mining, civil or geology engineering BSc. formation.
Objective (expected results of study and acquired competences)	• On the completion of this course, the participants shall acquire the ability to perform analytical solutions for problems involved in rock mechanics Eng. Field. The analytical technics are based on the: o Continuum media conditions, o Discontinuous media conditions.
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Theoretical Lecture
Further information	
Recommended reading	Jing, L., Stevenson, O., Fundamentals of Discrete Element Methods For Rock Engineering: Theory And Applications, 2007 Mase, G. Thomas, Mase, George E., Continuum Mechanics for Engineers, 2nd edition, 1999 Priest, S.D., Discontinuity analysis for rock engineering, 1992 Reddy, J. N. , An Introduction to Continuum Mechanics with Applications, Texas A&M University, 2007
Course goal achievement measures:	4 assignments (20%), 2.5-hr final exam (60%), Course project (20%)

Design & Planning of Underground Spaces

Course Nb	
Credits	3
Type	Lecture
Lecturer	Prof. K. Shahriar
Course description	
Content	• Type of underground spaces • Role of geology in underground space deign • In situ stress and its measurement • Induced stress and its distribution • Ground improvement techniques • Excavation of underground spaces in soft and hard ground • Stability analysis and support design using; empirical, observational, analytical and numerical methods • Different type of rock support and reinforcement systems • Stability analyse of underground spaces using structural methods • Effect of dynamic loading on underground space stability
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Basic knowledge on geology, • Good knowledge on rock mechanics & rock properties • Basic knowledge of statics & strength of materials

Objective (expected results of study and acquired competences)	The main objective of the course is to go over the fundamentals of underground spaces design for mining and civil engineering. The students are expected to enhance their understanding and skills of different design methods such as empirical, observational and analytical technics. The student achievements will be measured through two exams in the 5th and 10th weeks of semester, plus a final project assignment, and a final exam. It is expected that students submit a professional report on the project assignment. The quality of this report is an indicative of student achievements from the course. On completion of this course the participants shall be able: to employ different design methods in underground mining and civil engineering application, design of underground excavation and selection of most suitable support systems.
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Theoretical part: lecture Practical part: covers demonstration with short exercises on real data and a homework assignment with final presentation
Further information	
Recommended reading	Brady BHG, Brown ET. Rock mechanics: for underground mining, UK: Chapman & Hall; 1999 Feng X.-T., Hudson, J. H., Rock Engineering Design, 2011 Herget, G., Stresses in rock, Taylor & Francis, 1987 Hoek & Brown, Underground Excavations in Rock, 1980

	Hoek, E., Kaiser, P. K., Bawden, W. F., Support of Underground Excavations in Hard Rock Sinha, R., Underground structures, Design and instrumentation,
Note	The assessment methods and the compulsory readings of this course will be announced in detail in the first lecture.

Numerical Methods in Geomechanics

Course Nb	
Credits	3
Type	Lecture
Lecturer	Dr A. Mortazavi
Course description	
Content	• Introduction to numerical methods • Finite Element Method, Finite Difference, Method, Boundary Element method • Equation solvers • Components of a FEM program • Formulative procedures • Planar elements, Isoperimetric elements, Error analysis
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1)
Objective (expected results of study and acquired competences)	The main objective of the course is to cover the fundamentals of numerical modelling focusing on the finite element method. The students are expected to enhance their understanding of continuum mechanics principles within the context of numerical modelling. The focus of the course will be applied numerical modelling portraying the application of numerical methods in Geomechanics design. The student achievements will be measured through series of bi-weekly assignments, a final project assignment, and a final exam. It is expected that students submit a professional report on the project assignment. The quality of this report is an indicative of student achievements from the course. On completion of this course the

	participants shall be able to employ numerical methods in rock engineering applications
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lecture/programming/Assignments
Further information	
Recommended reading	Bathe, K.J., Finite Element Procedures in Engineering Analysis, Prentic Hall Ltd., 1982 Cook, R. D., Concepts & Applications of Finite Element Analysis, John Wiley & Sons, 3rd Ed., 1989, Naylor. D. J., Pande, G. N., Finite Elements in Geotechnical Engineering, Dieneridge Press, UK, 1981, All Notes Taught & Distributed in Class
Note	Have a fair knowledge of engineering mathematics

5. 2 Restricted Electives

Advanced Slope Stability

Course Nb	
Credits	2
Type	Lecture
Lecturer	Dr A. Mortazavi
Course description	
Content	• Mechanics of rock slopes • Input data and design parameters • Slope failure mechanisms • Slope design methods • In situ testing and slope monitoring
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1)
Objective (expected results of study and acquired competences)	The main objective of the course is to cover the fundamentals of rock slope engineering focusing on high slopes. The students are expected to enhance their understanding of advance rock mechanic principles within the context of slope stability. The focus of the course will be the design of high rock slopes as applied to mining and civil engineering. The student achievements will be measured through practical project assignment and a final project assignment, and a final exam. It is expected that students submit a professional report on the project assignment. The quality of this report and also the score achieved in the final exam are indicatives of student achievements from the course. On completion of this course the participants shall be able to design slopes and understand the mechanisms involved in high slopes

Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lecture/Assignments
Further information	
Recommended reading	Hoek, E., Rock Slope Engineering, 1988 All Geotechnical Engineering Text Books All notes taught & distributed in class
Note	Have a fair knowledge of engineering mathematics and advanced rock mechanics

Plasticity and Damage Mechanics in Rocks

Course Nb	
Credits	3
Type	Lecture
Lecturer	Dr H. Molladavoodi
Course description	
Content	elasticity theory; plasticity theory principles; elastic-plastic models for rock; phenomenological damage model; direct micromechanical damage mechanics micromechanical damage mechanics based on homogenization; plasticity and damage interaction numerical implementations
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Elasticity theory • Good background in engineering mathematics
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to have a profound knowledge of Rock damage and nonlinearity
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Theoretical lecture
Further information	
Recommended reading	

Rock Dynamics

Course Nb	
Credits	3
Type	Lecture
Lecturer	Dr A. Mortazavi
Course description	
Content	• Rock dynamics Fundamentals • Wave equation • Wave propagation in geomeaterials • Rock fragmentation by blasting & Blasting mechanisms • Application of mine induced seismicity to mine design • Dynamic properties of rocks
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1)
Objective (expected results of study and acquired competences)	The main objective of the course is to cover the fundamentals of rock dynamics focusing on the wave propagation, rock burst, and dynamic rock fragmentation. The students are expected to enhance their understanding of physics of wave propagation within geomeaterials and rock dynamic principles. The focus of the course will be blast-induced rock fragmentation and mine-induced seismicity as applied to the design of deep underground openings. The student achievements will be measured through a professional technical seminar and a final exam. It is expected that students present a professional oral seminar on a subject within the course scope The quality of this seminar and the score achieved in the final exam are indicatives of

	student achievements from the course. On completion of this course the participants shall be able to understand the dynamic problems in rock engineering applications
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lecture/Assignments
Further information	
Recommended reading	Persen, L. N., Rock Dynamics & Geophysical Exploration: Introduction to Stress Waves in Rocks, Elsevier Ltd., 1975 All Notes Taught & Distributed in Class
Note	Have a fair knowledge of engineering mathematics

Tunnel Basin Site Investigations

Course Nb	
Credits	3
Type	Lecture
Lecturer	Dr H. Molladavoodi
Course description	
Content	• introduction, importance of site investigation • alignment selection • geometric specification of tunnel • Data collection • surface geological investigation • Geophysics studies • Exploration boring • Exploration boring • Hydrology study • In situ tests • Engineering services for studies • Risk evaluation • Settlement evaluation • Settlement evaluation • Environmental evaluation • earthquake studies • site evaluation
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Rock & soil mechanics
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to • prepare data for feasibility study, • optimum choice selection, • optimum design • risk management

Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lecture
Further information	
Recommended reading	

6. Instituto Superior Técnico of the Universidade de Lisboa, Portugal

6. 1 Compulsory Subjects

Mine Exploitation

Course Number	
Credits	6
Type	Lecture / Practical
Lecturer	Paula Falcão Neves
Course description	
Content	• Underground mining methods classification (natural and artificially supported and by caving). • Main and auxiliary underground operations sequence. • Primary, secondary and terciary development. • Equipment selection. • Rock mass excavation with explosives and mechanical excavation. • New mining methods for very deep, low grade and sea level deposits.
Previous knowledge expected	• Good English skills • Basic knowledge of geomechanics, and mining operations
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to: • Conceive and design production operations related to underground mining (also appropriate to wide-ranging of underground works, including those with civil purpose),

	attending all the legal compelling restrains and with the fundamentals of Sustainable Development.
Language of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lecture Underground mining project
Further information	
Recommended reading	SME Mining Engineering Handbook, Vol I, II, SME Ed. Peter Darling, 2011 Introductory Mining Engineering, H. Hartman, 2002, Ed. John Wiley and Sons
Note	The assessment methods and the compulsory readings of this course will be announced in detail in the first lecture. The latest version of the lecture notes will be uploaded at the beginning of the semester.

Mineral and Solid Waste Processing I

Course Number	
Credits	6
Type	Lecture / Practical
Lecturer	Fernando de Oliveira Durão Carlos Alberto Alonso da Costa Guimarães
Course description	
Content	Comminution. Characterization of comminution process. Objective. Size Reduction. Mineral Liberation. Different stages of comminution process.Primary Crushing Process characterization. Selection of the equipment. Secondary and Fine Crushing. Process characterization. Selection of the equipment. Grinding Process characterization. Selection of the equipment. Plant Flow Sheets ? Classification. Process characterization. Different stages of classification process. Screening Selection of screens. Hydroclassification. Cyclone classifiers selection. Comminution-Classification Circuits. Design and prediction of results. Case study report discussion. Visit to an industrial processing plant.
Previous knowledge expected	• Good English skills
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to: • Synthesize, design and analyse general comminution-classification circuits

	• Select and size main equipment, namely coarse and fine crushing equipment, milling/grinding equipment, mechanical (industrial screening), gravity (gravity classifiers) and centrifuge (hydrocyclones) classification equipment.
Language of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lecture Underground mining project
Further information	
Recommended reading	• Kelly, G., K., Spottiswood, E., G.: Introduction to Mineral Processing, John Wiley & Sons Inc, 1982 • Will, B. & Napier-Munn, T.: Mineral Processing Technology, Elsevier, 2006 • Science and Technology books
Note	The assessment methods and the compulsory readings of this course will be announced in detail in the first lecture. The latest version of the lecture notes will be uploaded at the beginning of the semester.

Open Pit Mining and Quarrying

Course Number	
Credits	6
Type	Lecture / Practical
Lecturer	Paula Falcão Neves
Course description	
Content	.Fundamental principles for open pit mining and quarrying .Methodologies for: - industrial and metal ore deposits with and without explosive use exploitation techniques - ornamental stone exploitation techniques (surface and underground methods). - Dimension stones processing (limestone, marble and granite). -Environmental, health and safety aspects are referred. -Exploitation projects applied to real deposits (industrial and dimension stones).
Previous knowledge expected	• Good English skills • Basic knowledge of geomechanics, and mining operations
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to: • Design and execute exploitation projects of open pit mines, quarries, and dimension stone processing of marble and granite.
Languages of instruction	English

Teaching and learning method (delivery of skills) workload for students	Lecture Surface mining project (metals, industrial minerals or dimension stones)
Further information	
Recommended reading	• Darling, P. (ed.): SME Mining Engineering Handbook, Vol I, II, SME, 2011 • Hustrulid, W., Kuchta, M.: Open pit planning and design, 2nd ed.,Taylor & Francis, 2006
Note	The assessment methods and the compulsory readings of this course will be announced in detail in the first lecture. The latest version of the lecture notes will be uploaded at the beginning of the semester.

Soils and Rocks Dynamics

Course Number	
Credits	6
Type	Lecture / Practical
Lecturer	Pedro Bernardo Gustavo Paneiro
Course description	
Content	• Stress waves and propagation on soils and rocks • Dynamic internal friction. Attenuation • Reflection of elastic waves on a free surface. Reflection and refraction at the surface separating two physical media • Experimental investigations of dynamic elastic properties • Mechanisms of rock fragmentation by explosives • Environmental control of vibrations; Safety criteria for structures
Previous knowledge expected	• Good English skills • Previous knowledge about basic geomechanics and blast design concepts.
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to: • Assess the propagation stress waves and analyse the fracture and fragmentation caused by detonations • Evaluate the dynamic behaviour of rock masses • Measure the dynamic properties "in situ" and know the criteria for structural safety under the effect of vibrations
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lecture. Active participation and discussion

Further information	
Recommended reading	• Hartmann, H. H. (ed.): S.M.E. Mining Engineering Handbook, 2nd ed., Society for Mining, Metallurgy, and Exploration, Inc., Colorado, 1992 • Mavko et al.: The Rock Physics Handbook – Tools for Seismic Analysis of Porous Media, 2nd ed., 2009
Note	The assessment methods and the compulsory readings of this course will be announced in detail in the first lecture. The latest version of the lecture notes will be uploaded at the end of each lesson.

6. 2 Restricted Electives

Geophysical Data Processing

Course Number	
Credits	6
Type	Lecture / Practical
Lecturer	Leonardo Azevedo
Course description	
Content	• Overview of basic concepts common to all methods related with digital signal processing: signal and noise; ADC; sampling theorem; Fourier analysis. • Overview of main principles for potential methods (gravimetric and magnetics). • Data processing and applications with field examples. • Overview of the seismic method, main principles and applications. • Seismic acquisition layouts. • Seismic processing workflows. • Velocity analysis and near-surface models. • Introduction to seismic imaging.
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Basic knowledge of geology and geophysics
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to: • Understand main principles and applications potential and non-potential methods; • Apply small processing steps to field data • Distinguish real signal from noise/artefacts
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lecture Active participation and discussion Semester assignment for real data processing

Further information	
Recommended reading	• Geldart, L. P., Telfor, W., M. and Sheriff, R.: Applied Geophysics. Cambridge University Press 1990 • Öz, Y.: Seismic Data Analysis: Processing, Inversion and Interpretation of Seismic Data, Society Of Exploration Geophysicists, 2001
Note	The assessment methods and the compulsory readings of this course will be announced in detail in the first lecture. The latest version of the lecture notes will be uploaded at the beginning of the semester.

Geostatistics

Course Number	
Credits	6
Type	Lecture / Practical
Lecturer	Amilcar Soares/Mª João Pereira
Course description	
Content	• Natural Resources Models in the Framework of Probabilistic Formalism. • Geostatistical models. • Analysis of spatial continuity pattern of Natural Resources: Variogram and Spatial Covariance. • Geostatistical Linear Estimator. Kriging of Mean in Local Areas. Simple Kriging. • Practice of Kriging in Mine resources evaluation. • Application of Geostatistics to Mining Resources and Reserves Evaluation
Previous knowledge expected	• Good English skills (Minimum: CEF Level B1) • Basic knowledge of geology and statistics
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to: • Understand main principles of Mining Geostatiscs ; • Apply basic tools to estimate local resources and reserves
Languages of instruction	English

Teaching and learning method (delivery of skills) workload for students	Lecture Active participation and discussion Semester assignment for real data application
Further information	
Recommended reading	• Geldart, L. P., Telfor, W., M. and Sheriff, R.: Applied Geophysics. Cambridge University Press, 1990 • Öz, Y.: Seismic Data Analysis: Processing, Inversion and Interpretation of Seismic Data, Society Of Exploration Geophysicists, 2001
Note	The assessment methods and the compulsory readings of this course will be announced in detail in the first lecture. The latest version of the lecture notes will be uploaded at the beginning of the semester.

Mine Wastes Management and Deposition Technologies

Course Number	
Credits	6
Type	Lecture / Practical
Lecturer	Maria Matilde Hort Costa e Silva
Course description	
Content	• Mine fill materials: Rock wastes, tailings, mixtures with natural sand and aggregates and pozzolans. • Properties of fill materials: sizing, shape, permeability, mineralogy, tailings oxidation, and other pollutant properties. • Improvements in safety underground works using backfill. Interaction between rock mass / backfill. • Technology for deposition: filling by gravity, hydraulic fill, paste fill, discharge in tailings dams. • Tailings dams construction methods (upstream, downstream and centerline). Hazards, Risks and Environment Management. Monitoring.
Previous knowledge expected	• English • Basic knowledge of mining exploitation
Objective **(expected results of study and acquired competences)**	On completion of this course the participants shall be able to: • Select the best mine fill material, the adequate methodology and technology of deposition for underground or surface mine works.
Language of instruction	English

Teaching and learning method (delivery of skills) workload for students	Lecture Active participation and discussion with solution of practical problems.
Further information	
Recommended reading	• Lottermoser, B.G.: Mine Wastes. Characterization, Treatment and environmental Impacts 2010, 3rd ed., Springer, 2010 • Potvin, Y., Thomas, E.G., Fourie, A.B.: Handbook of Mine Fill, Australian Centre for Geomechanics, 2005
Note	The assessment methods and the compulsory readings of this course will be announced in detail in the first lecture. The latest version of the lecture notes will be uploaded at the beginning of the semester.

Safety, Health and Environment

Course Number	
Credits	6
Type	Lecture / Practical
Lecturer	Maria Matilde Horta Costa e Silva
Course description	
Content	Introduction: main concepts and standards of safety, health and environment. Risk analysis in underground and surface works. Underground atmosphere quality: temperature, humidity, gases and dust. Explosives atmospheres and fire prevention. Lightning. Ventilation. Water quality. Dust emission. Damage and human discomfort due to noise and ground vibrations. Environmental impacts in biosphere. Safety equipment and signalling. EMS/ ISO 14001. EHSMS. Implementation, management and control of safety, health and environment program.
Previous knowledge expected	• English • Basic knowledge of underground and open pit mining
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to: • Implement, manage and control safety, health and environment issues related to mining activities.
Language of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lecture Safety and environmental restoration plan.

Further information	
Recommended reading	• Darling, P. (ed.): S.M.E. Mining Engineering Handbook, Society for Mining, Metallurgy, and Exploration, Inc., Vol.2, Part 15,16: Portuguese Legislation
Note	The assessment methods and the compulsory readings of this course will be announced in detail in the first lecture. The latest version of the lecture notes will be uploaded at the beginning of the semester.

GERMAN - MONGOLIAN INSTITUTE FOR RESOURCES AND TECHNOLOGY

Underground Mining Methods

Course Nb	
ECTS	6 CP
Type	Lecture / Tutorial
Lecturer	Vossen
Course description	
Content	• Historical Development of Mining Methods • Classification of Mining Methods • Unsupported Mining Methods • Backfilling and Supported Mining Methods • Caving Methods • Criteria and Selection of the suitable Mining Methods according to the deposit • Planning and Design of the Mining Process (development, extraction, loading, hauling, hoisting, cycle times, production capacity) • Planning and Design of Auxiliary Processes
Previous knowledge	• Good English skills (CEF Level C1)
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to • select an underground mining methods (for a given deposit); • develop a basic mine design, mine development plan and mining plan.
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lecture, Recitation UoIL 2, UoIR 2

Further information	
Recommended reading	• P. Darling (2011). SME Mining Engineering Handbook, Englewood: SME. • W. A. Hustrulid; R. L. Bullock (2001). Underground Mining Methods: Engineering fundamentals and international case studies, Littleton, Colorado: SME. • Potvin, Y.; Thomas, E.; Fourie, A. (Ed.) (2005). Handbook on Mine Fill. Nedlands, Western Australia: Australian Centre for Geomechanics.

Open Pit Mining and Quarrying

Course Nb	
ECTS	6 CP
Type	Lecture / Tutorial
Lecturer	Vossen
Course description	
Content	• Discontinuous and Continuous Open Pit Mining Methods • Mass Calculations of Deposit and Overburden • Dimensioning of the Mine Equipment • Planning Mining Process (extraction, loading, hauling, cycle times, production capacity) • Quarrying on Natural Stone and Industrial Minerals • Ashlar Mining • Environmental Issues and Mine Closure
Previous knowledge	• Good English skills (CEF Level C1)
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to • select an Open Pit Mining Method (for a given deposit); • understand the special Demands of Quarry Mining on Natural Stone and Industrial Minerals.
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lecture, Recitation, Excursion UoIL 2, UoIR 1, UoIExc 1
Further information	
Recommended reading	• Hartman, H. and Mutmansky, J.M. (2015). Introductory Mining Engineering

	• Darling et. al. (2011). SME Mining Engineering Handbook • Hustrulid, W.A. (2013). Open Pit Mine Planning and Design. CRC Press

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Soil and Rock Dynamics

Course Nb	
ECTS	6 CP
Type	Lecture / Tutorial
Lecturer	Vossen
Course description	
Content	• Geophysical Rock and Soil Properties • Soil Compression, Shear Resistance, Cohesion • Mining Rock Classification Methods • Rock Bolting in Underground Mining • Supporting Constructions in Underground Mining • Pillars Dimensioning in Underground Mining • Stability of Slopes in Open Pit Mining • Slope Slidings during Mining Operations – Prevention and Safety Procedures
Previous knowledge	• Good English skills (CEF Level C1)
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to • understand soil and rock dynamics; • dimension and select safe underground road heading methods; • evaluate and estimate rock and soil behavior to construct safe slopes.
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lecture, Recitation, Laboratory UoIL 2, UoIR 1, UoILab 1

Further information	
Recommended reading	• Verruijt, A. (2012). Soil Mechanics; Delft University of Technology • Kenew, A.E. (2014). Geology for Engineering Scientists, Pearson • Mah, C.; Wyllie, D. (2004). Rock Slope Engineering. Civil and Mining, 4th edition.

Mineral and Solid Waste Processing

Course Nb	
ECTS	6 CP
Type	Lecture / Tutorial / Laboratory
Lecturer	Vossen
Course description	
Content	• Design and calculation of mineral processing plant components (Crushing, classification, sorting, drainage, drying, conveyor technology, bunkers) • Design and calculation of waste processing plant components • establishment of mass and water balances, list of machines, infrastructure • Estimation of environmental damage and necessary • Location layout, logistics, and approval requirements • Sensor based waste sorting, machine types and operating conditions
Previous knowledge	• Good English skills (CEF Level C1)
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to • plan processing plants of primary and secondary raw materials; • involve technical, economic, legal and environmental viewpoints; • understand the technical basics of main sorting methods.
Languages of instruction	English

Teaching and learning method (delivery of skills) workload for students	Lecture, Recitation, Laboratory UoIL 2, UoIR 1, UoILab 1
Further information	
Recommended reading	• Weiss, N.L. (1985). SME Mineral Processing Handbook, New York: Society of Mining Engineers • Wills B.A. (1988) Mineral Processing Technology", 4. Edt., Pergamon Press, Oxford • Fuerstenau M.C. (2003). Principles of Mineral Processing, Society of Mining Engineers • Pichtel, J. (2014). Waste Management Practices. CRC Press

Heap Leaching and Metal Recovery

Course Nb	
ECTS	6 CP
Type	Lecture / Tutorial
Lecturer	Bayanmunkh
Course description	
Content	• Usage of Heap Leaching • Ore Preparation and Stacking • Irrigation Process • Metal Recovery/Extraction • Emissions and Environmental Impacts • Commercial Applications of Heap Leaching • Alternative Leaching Methods
Previous knowledge	• Good English skills (CEF Level C1)
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to • interpret and apply the heap leaching process in production; • utilize of plant principles and design in general; • understand emissions and environmental impacts of heap leaching process.
Language of Instruction	English
Teaching and learning method (delivery of skills) workload for students	Lecture, Recitation, Excursion UoIL 2, UoIR 1, UoIExc 1
Further information	
Recommended reading	• Free, M. L. (2013). Hydrometallurgy, Fundamentals and Application, Wiley • Jackson E. (1986). Hydrometallurgical Extraction and Reclamation, Ellis Horwood Limited

	• Weiss N. L. (1985). SME Mineral Processing Handbook, Vol. 2.

Mine Waste Management and Deposition Technologies

Course Nb	
ECTS	6 CP
Type	Lecture / Tutorial
Lecturer	Vossen
Course description	
Content	• Mine Waste • Acid Mine Drainage • Mine Water • Tailings • Emissions and Environmental Impacts • Management of Mining Waste • Radioactive Mine Waste
Previous knowledge	• Good English skills (CEF Level C1)
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to • understand the environmental footprint of mining operations in general; • develop concepts and measures to minimize the environmental footprint.
Languages of Instruction	English
Teaching and learning method (delivery of skills) workload for students	Lecture, Recitation, Excursion UoIL 2, UoIR 1, UoIExc 1
Further information	
Recommended reading	• Lottermoser, B.G. (2010). Mine Wastes: Characterization, Treatment and Environmental Impacts. 3rd edition. Springer-Verlag • Spitz, K., Trudinger, J. (2009). Mining and the Environment. CRC Press

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Safety, Health and Environment in Mining and Processing

Course Nb	
ECTS	6 CP
Type	Lecture / Tutorial / Excursion
Lecturer	Vossen
Course description	
Content	• Factors influencing productivity and occupational safety • National and international occupational safety • Risk assessments and protective measures, ergonomics • Biological and psychological stress • Work Safety in Mining - Weather protection - Water flow off rate - Subsidence control - Ground movements - Flood protection - Fire protection, explosion protection - Mine rescue - Dust and noise, gaseous emissions
Previous knowledge	• Good English skills (CEF Level C1)
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to • describe the methods and instruments for protection of the workplace in a mine; • learn methods for the prevention of accidents at work; • carry out risk assessments and deal with hazardous substances; • list the risks and stress factors and evaluate emission and immission.
Languages of instruction	English
Teaching and learning method (delivery of skills) workload for students	Lecture, Recitation, Laboratory UoIL 2, UoIR 1, UoIExc 1

Further information	
Recommended reading	• Center for the Advancement of Process Tech (2009). Safety, Health, and Environment” • Asfahl, C.R.; Rieske, D.W. (2010). Industrial Safety and Health Management, 6th Edition, Pearson Publishing • Mongolian Law (Law on Occupational Safety and Health), 2008-05-22, printed version, MNG-2008-L-82767

Natural Resources and Investigation Methods

Course Nb	
ECTS	6 CP
Type	Lecture / Tutorial / Laboratory
Lecturer	Herd
Course description	
Content	• "Geology of Mongolia" - regional geodynamic evolution and tectonics - geological units of Mongolia, their distribution and properties - magmatic and volcanic activities over time • Excursion: "Resource potential and typical raw material deposits of Mongolia" • Field Training: "Investigation methods and techniques"
Previous knowledge	• Good English skills (CEF Level C1)
Objective (expected results of study and acquired competences)	On completion of this course the participants shall be able to • describe the geodynamic evolution of the region; • differentiate the geological units and their distribution; • estimate the resource potential of the different units and regions; • describe the distribution of raw material deposits in Mongolia; • recall the state-of-the-art investigation methods.
Languages of Instruction	English
Teaching and learning method (delivery of skills) workload for students	Lecture, Recitation, Laboratory UoIL 1, UoIExc 2, UoIR 2

Further information	
Recommended reading	• Evans, A. M. (1992). Ore Geology and Industrial Minerals. Blackwell. Oxford. • Lillesand, T. M.; Kiefer, R. M.; Chipman, J. W. (2008). Remote sensing and image interpretation. Wiley. Hoboken. • Reynolds, J. M. (2011). An introduction to applied and environmental geophysics. Wiley-Blackwell. Chichester. • Vogelsang, D. (1995). Environmental Geophysics. Springer. Berlin.