BOOK OF SUBJECTS

MINING ENGINEERING

DOCTORAL ACADEMIC STUDIES
(III LEVEL OF ACADEMIC STUDIES)

2023

Content – list of subjects

Course: Geostatistics

Lecturer: dr Saša S. Stojadinović, vanr. prof.

Course status: Elective

ECTS:15

Prerequisites: -

Course goal
Introduction to spatial or spatio-time data sets, geostatistic analysis and modeling of georeferenced spatial data.

Course outcome
Through consultations, students will be able to get acquainted and deeper understanding of statistical techniques, as well as techniques of creating, editing, analyzing and modeling georeferenced spatial data.

Course description
Theoretical and practical consultative teaching: Introduction to statistics and geostatistics as a science. Get acquainted with the basic geostatistical terms, methods and its application. Introduction to: a/ basics of analysis (spatial, univariate, bibiriate, multivariate), b/ geometric algorithms (triangulation and network representation), v/ methods of interpolation and valuation (variogram, g / geostatistic simulation. Introduction to software tools including geographic information systems (GIS) for solving geostatistic problems.

Recommended literature
Ye Zhang, Introduction to Geostatistics. University of Wyoming, Dept. Of Geology & Geophysics, 2011.
John C. Davis, Statistics and Data Analysis in Geology. John Wiley & Sons, 1986.
Mario E. Rossi, Clayton V. Deutsch, Mineral Resource Estimation, Springer, 2014.
Richard Webster, Margaret A. Oliver, Geostatistics for Environmental Scientists, 2009.
Steve McKillup, Melinda Darby Dyar, Geostatistic Explained, Cambridge, 2010.

Number of classes per week	**Lectures: 6**	**Practical classes: 4**

Lecture methods
Lectures with interactive discussions, consultations, study research (SIR)

Grading (maximum 100 points)
activity during the lecture: 10 points
SIR: 40 points
Oral exam: 50 points

Method of testing: exam, asignment

Course: NUMERICAL METHODS IN GEOMECHANICS

Lecturer/s: Dr Radoje Pantović, full professor

Status of the course: Elective course

ECTS: 15

Prerequisite: Completed course of Rock and soil mechanics

Course goals: Introduction to theoretical foundations and application of numerical methods in geomechanics. Understanding rock mass behavior around excavations. Underground facilities design and support definition upon numerical methods results.

Learning outcomes:

Individual competences for numerical methods application in mine design.

Course description:

Lectures:

Development and application of numerical methods. Purpose of numerical methods in geomechanics. Procedures of numerical modeling. Numerical modeling of stress/strain state around excavation. Theoretical background of physical phenomena: theory of elasticity and plasticity, block theory and boundary conditions. Basic equations of static and dynamic behavior. Continuous and laminar models of stratified rock mass. In situ stress. Theoretical foundations and application of finite element methods. Linear analysis, elastic – plastic analysis, rock failure criteria. Formulation of failure conditions. Stress/strain relations. Critical state model. FEM application. Slope stability. Chamber stability calculations using FEM. Ground subsidence and ground surface deformation phenomena. Water flow in rock mass modeling. Theoretical fundaments of finite differences, finite elements and discrete elements methods. Statistical and deterministic approach to excavation dimensioning.

Practice:

Assignment – use of numerical modeling software

Literature:

Recommended:

1. M. Stević, Mehanika tla i stijena, RGF, Tuzla, 1991.

2. N. Gojković, R. Obradović, V Čebašek, Stabilnost kosina površinskih kopova, RGF, Beograd, 2004.

3. E. Hoek, Practical Rock Engineering, 2000.

4. E. Hoek, P.K. Kaiser, W.F. Bawden: Support of Underground Excavations in Hard Rock, 1995.

Ancillary:

1. E. Hoek, Practical Rock Engineering, 2000.

2. E. Hoek, P.K. Kaiser and W.F. Bawden, Support of Underground Excavations in Hard Rock, 1995.

Number of classes per week	**Lectures: 6**	**Practical classes: 4**

Teaching methods

Oral lectures, laboratory and calculus practicals, discussion

Knowledge evaluation (maximum 100 points)

Exam 40, independent work 40 and activity during classes and study research work 20.

Course: REMOTE SENSING

Lecturer: dr Saša S. Stojadinović, vanr. prof.

Course status: Elective

ECTS:15

Prerequisites:-

Course goal

Introducing students to the basic principles of remote sensing, sensor operation and data collection and processing .

Course outcome

The ability of students to design a remote sensing system and explore the possibilities of application in the mining environment as well as to observe and analyze the effects of application.

Course description

Theoretical classes

Remote sensing in a narrow sense, Remote sensing in a broad sense, Sensors, Sensor installations , Data transfer method, Acquisition systems, Data processing, analysis and interpretation , Targeted detection, Big data, Possibilities of application of remote detection in the mining environment, Decision systems based on collected data, Possibilities of process automation / process parts .

Practical classes

Research work on a predefined topic for real conditions in the mining environment.

Recommended literature

H. S. Düzgün, N. Demirel, Remote Sensing of the Mine Environment, CRC Press, 2011

Number of classes per weak	Theoretical:	6	Practise:	4

Lecture methods

Auditory lectures, consultations during the study research

Grading (maximum 100 points)

Assignment 40

Oral 60

Course: BLOCK METHODS

Lecturer/s: Dr Radoje Pantović, full professor

Status of the course: Elective course

ECTS: 15

Prerequisite: It is not intended.

Course goals:

Detailed familiarization of students with the conditions and procedures of excavation using block methods.

Learning outcomes: The ability of the student to make qualified decisions about the selection, design of parameters and application block methods.

Course description:

Lectures:

Methods of block mining. Methods of block excavation with crushing of ore and accompanying rocks. Methods of block forced demolition. Methods of forced single-stage crushing with ore blasting in a confined environment. Methods of block one-stage forced sub-stretch crushing. Methods of block one-stage forced storey demolition. Methods of forced two-stage crushing. Methods of forced two-stage crushing with vertical compensation chambers. Methods of forced two-stage crushing with horizontal compensation chambers. Methods of block mining with self-crushing ore. Methods of block (story) self-claying. Methods of panel self-grinding. Methods of continuous self-crushing and extraction of ore. Methods of block crushing with ore storage. Excavation method with surface preservation (with excavation filling). Method of block excavation with leaving pillars and filling the excavation space. Method of block excavation with leaving an empty excavation space (with open excavations)

Practice:

Preparation of a seminar paper.

Literature:

Recommended:

1. Milićević Ž. Metode podetažnog i blokovskog zarušavanja. Tehnički Fakultet u Boru, Bor 2008.

Ancillary:

2. Additional literature as recommended by the lecturer.

Number of classes per week	**Lectures: 6**	**Practical classes: 4**

Teaching methods

Teaching is conducted in the form of lectures and auditory exercises with an effort to involve the students as much as possible, i.e. to be interactive.

Knowledge evaluation (maximum 100 points)

Seminar paper 50, oral exam 50.

Course: GEOMONITORING

Lecturer/s: Dr Radoje Pantović, full professor

Status of the course: Elective course

ECTS: 15

Prerequisite: Knowledge acquired at basic and master's academic studies.

Course goals: Acquaintance of students with the basic principles of application of instrumentation for in-situ and laboratory monitoring of the behavior of rock mass, soil and objects.

Learning outcomes: Acquaintance of students with the basic principles of application of instrumentation for in-situ and laboratory monitoring of the behavior of rock mass, soil and objects.

Course description:

Lectures:

General philosophy of geomonitoring. Instrumentation levels. Types of monitoring. Sensors. Instruments. Measurement of deformations, forces, pressure, vibrations, temperature. Measuring systems. Analysis and interpretation of collected data. Signal conditioning, Error analysis. Geomonitoring of water in the soil. Instruments for measuring soil pore pressure. Types of piezometers. Measurement of displacements and deformations. Vertical and horizontal movements of buildings and soil. Rod and magnetic extensometers. Inclinometers. Data interpretation. Seismic monitoring with highly sensitive equipment for monitoring and analyzing induced and natural seismicity, either above ground, underground or as lowered installations in mining. Vibrating wire instruments and local stress measurement. Basic mechanics of vibrating string instruments and linear strain measurement. Interpretation of data obtained using vibrating wire instruments. Data interpretation. Pressure cells. Monitoring of changes in cracks and damages. Monitoring of ground movements and deformations of the earth's surface and infrastructure facilities using complex geodetic measurement systems that use GNSS, total stations, laser scanners, remote sensing and control methods. Use of automatic total stations. Prisms. Advanced optical systems. Special instruments. Bassett's convergence system. Geometrical principles of the rod. Data collection and processing. Optical systems.

Practice:

Immediate familiarization with measuring equipment, instruments and measuring technique. Creation of a monitoring project for buildings or larger spatial entities.

Literature:

Recommended:

1. R. Bassett, A Guide to Field Instrumentation in Geotechnics, Principles, installation and reading, ISBN -13: 978-0-203-80924-2, 2013

Ancillary:

2. Corresponding EUROCOD and EN standards

3. Internet literature

Number of classes per week	**Lectures: 6**	**Practical classes: 6**

Teaching methods

Lectures, exercises, field teaching.

Lectures with interactive discussions, consultations, SIR, preparation of reports.

Knowledge evaluation (maximum 100 points)

Activity during classes and exercises 20, seminar paper 40 and exam 40.

Course: MOVEMENT OF UNDERMINED TERRAIN AND PROTECTION OF OBJECTS

Lecturer/s: Vušović M. Nenad

Status of the course: Elective for ELMS module students

ECTS: 15

Prerequisite: Prior knowledge of Geodesy, Mine Surveying, Geoinformatics and GIS

Course goals: Familiarization of students with the problem of movement of undermined terrain and the protection of structures above underground mining works, deformations that occur on the surface of the terrain and on objects in the zone of influence of mining works, the method of construction of protective pillars for natural and technical objects on the surface of undermined terrain, methods of forecast calculation settlement and deformation on the surface of the undermined terrain during the excavation of horizontal and inclined coal seams.

Learning outcomes: Acquisition of knowledge in the area of the movement of undermined terrain and the protection of buildings from the impact of mining operations, geometric characteristics of the movement process, methods for the forecast calculation of movement and deformations of undermined terrain, designing networks for observing the movement of undermined terrain, observing deformations on buildings and processing the results of measurements

Course description:

Lectures: Historical presentation of the problem of moving the undermined terrain. Excavation as a cause of movement of undermined terrain. Display of the displacement process in the massif. General observations on redistribution primary underground pressure. Basic concepts in the problem of moving the undermined terrain. Terms, definitions and symbols. Geometric characteristics of the displacement process. Basic linear elements. Parameters and deformation curves of the terrain surface. Angular parameters of the displacement process. Classification of methods for prognostic calculation of displacement processes and deformations of undermined terrain. Forecast values for mines with an unstudied displacement process. Empirical methods of calculating the displacement of undermined terrain. Calculation methods based on the application of the distribution function. Calculation methods based on the mechanics of continuous media. Stochastic method of calculation of displacement of undermined terrain. Calculation methods based on the application of neural networks. Movement of undermined terrain in metal and non-metal mines. Perception of movement of undermined terrain. Parameters of the largest displacements and deformations: absolute maximum settlement, maximum horizontal displacement. Angular parameters: empirical patterns for determining the angle of maximum lie and limit angles. Protective pillars. Protection criteria i permissible deformations for certain categories of objects. Construction of protective columns for: building, shaft and roads. Damage to objects and compensation to owners.

Practice: Theoretical teaching is followed by practical exercises and studio research work which includes calculations of settlement values at arbitrary points of the surface of the undermined terrain at excavation of a horizontal and/or inclined layer with the collapse of the roof using the stochastic method budget. Creation of a project of a network for observing the movement of undermined terrain. Processing of measurement data. Calculation of the maximum values of displacement parameters and deformations on the surface of the undermined terrain. Calculation maximum values of displacement and deformation parameters.

Literature:

Recommended:

1. Ђорђевић Д., Вушовић Н.: Прогнозни прорачун померања и деформација поткопаног терена, Рударскогеолошки факутет, Београд (2014)
2. Патарић М., Стојановић А.: Померање поткопаног терена и заштита објеката од рударских радова, Рударско-геолошки факутет, Београд, (1994)
3. Peng S. S.: Surface subsidence engineering. United States (1992)

Ancillary:

1. Whittaker, B.N., Reddish D.J.: Subsidence: occurrence, prediction and control. Netherlands (1989)

Number of classes per week	**Lectures: 6**	**Practical classes: 4**

Teaching methods Lectures and exercises will be held in the Center for GIS, with the use of the original MITSOUKO software for calculating the values of lying at arbitrary points using the stochastic calculation method and ArcGIS software, supported by the student service https://moodle.tfbor.bg.ac.rs

Knowledge evaluation (maximum 100 points) study research paper 20 points; written exam 30 points; oral exam 50 points.

Course: THEORETICAL PRINCIPLES OF COMMINUTION AND CLASSIFICATION

Lecturer/s: PhD Milan Trumić, full professor; PhD Maja Trumić, associate professor

Status of the course: Elective

ECTS: 15

Prerequisite: Acquired knowledge from the subject of comminution and classification of materials

Course goals:

Introducing students with theoretical and fundamental principles, on which comminution and classification are based, using modern approach and concrete examples as well as modern software in this area.

Learning outcomes:

Students have theoretical and practical knowledge and are trained to work in comminution and classification plants and they have a basis for further individual specialization.

Course description:

Lectures: Fundaments of particles breakage: mathematical liberation models (Gaudin, Griffith, Rittinger, Kick, Bond theory). Modelling of flow in crushers and mills. Theoretically and empirically calculation of mill power. Optimal ball size distribution in mill. Modelling of grinding process. Optimal value of circulation ratio. Grindability of materials. Theoretical basics of screening. Modelling of screening process. Theoretical basics of classification. Modelling of classification process.

Literature:

Recommended:

1. N. Magdalinović, Usitnjavanje i klasiranje, Nauka, Beograd, 1999.
2. N. Magdalinović, Usitnjavanje i klasiranje mineralnih sirovina-praktikum, Tehnički fakultet, Bor, 1985.
3. N. Magdalinović, Meljivost mineralnih sirovina, Nauka, Beograd, 1997.
4. N. Magdalinović, I. Budić, N. Ćalić, R. Tomanec, Kinetika mlevenja, Tehnički fakultet, Bor, 1994.
5. Mineral Processing Handbook 7/07, Telsmith, Inc., USA, 2007.
6. Barry A. Wills, Tim Napier-Munn, Mineral Processing Technology, Publisher: Elsevier Science and Technology Books, Pub. Date: October, 2006.
7. A.Gupta and D.S.Yan, introduction to Mineral Processing Design and Operation, Perth, Australia, January, 2006
8. Using literature from available databases (SCOPUS, SCIENCEDIRECT, WEB of SCIENCE, PROQUEST, COMPENDEX)

Number of classes per week	**Lectures: 6**	**Practical classes: 4**

Teaching methods

Classical lectures with consultant approach to independent work of students, preparation of seminar work and study research work.

Knowledge evaluation (maximum 100 points)

40 % oral exam + 40 % seminar paper + 20 % defense of seminar paper

Course: MICRONIZATION, MECHANICAL AND MECHANOCHEMICAL ACTIVATION OF MINERALS

Lecturer/s: PhD Milan Trumić, full professor

Status of the course: Elective

ECTS: 15

Prerequisite: Requires knowledge of comminution and classification

Course goals:

Introduction to students with the basics of theoretical and practical principles of the micronization process, mechanical and mechanochemical activation. In addition, the goal is to get acquainted with the machines and devices used in the micronization process, mechanical and mechanochemical activation. Studying with the basic types of special mills and their construction, students will also get acquainted with the new features of raw materials treated in the process of micronization, mechanical and mechanochemical activation as well as the possibilities of their application in various branches of industry.

Learning outcomes:

Acquiring knowledge on the theoretical and practical principles of the micronization process, mechanical and mechanochemical activation, and the ability to apply these knowledge in micronization processes. Acquired knowledge forms the basis for further individual training in this field.

Course description:

General basics and important properties of solid bodies. Ideal and realistic crystals. Deformations and defects of crystal lattice crystals.

Basic principles of grinding and selected examples of estimation of the efficiency of the micronization process, mechanical and mechanochemical activation.

The current situation and the development of principles and devices for the crushing of special purposes. Selected methods for analysis of powdery raw materials and determination of energy consumption in fine and ultra fine milling minerals.

Mechanical activation in high-energy mills.

Converting and transferring energy during grinding.

The role of additives for grinding on the environment in the mechanical activation of minerals.

Micronization, mechanical and mechanochemical activation of minerals and intermediate products obtained in mining and chemical industry, etc..

Literature:

1. В.И.Молчанов, Т.С. Юосупов, "Физические и хемические своиства тонко-диспергированных минералов", Недра, Москва, 1981.
2. Gerhard Heineke, Hans Peter Henning, Eberhard Linke, Ursula Steinike, Peter Adolf Thiessen: "Tribochemistry", Akademie-Verlag-Berlin, 1984.
3. В.И. Молчанов, О.Г. Селезнева, Е.Н. Жирнов: "Активация минералов при измельчении", Недра, Москва, 1988.
4. K. Tkáčová: "Mechanical Activation of Minerals", ELSEVIER, 1989.
5. Nedeljko Magdalinović: "Energija usitnjavanja", Univerzitet u Beogradu, tehnički fakultet Bor, 1992.
6. Momčilo M. Ristić: "Principi nauke o materijalima", Beograd, 1993.
7. P. Baláž, Slovak Academy of Sciences, Košice, Slovakia: " Mechanochemistry in Nanoscience and Minerals Engineering", ISBN 978-3-540-74854-0, Springer, 2008.
8. Andrić Lj., Trumić M.: Monografija: "USITNjAVANjE MLEVENjEM - Mikronizacija, mehanička i mehanohemijska aktivacija minerala", Univerzitet u Beogradu, Tehnički fakultet Bor, ISBN 978-86- 6905-013-6, COBISS, SR-ID 201968652, Bor 2013.
9. Current literature, as recommended by the teacher.

Number of classes per week	**Lectures: 6**	**Practical classes: 4**

Teaching methods

Classical lectures with consultant approach to independent work of students, preparation of seminar work and SIR.

Knowledge evaluation (maximum 100 points)

Exam 40 % + seminar paper 40 % + seminar work presentation 20 %

Course: Theory of physical process of concentration

Lecturer/s: PhD. Jovica M. Sokolović, full professor

Status of the course: Elective for Mining Engineering

ECTS: 15

Prerequisite: Acquired knowledge at undergraduate and master's academic studies

Course goals: Study of the theoretical basis on which the physical methods of concentration of mineral or secondary raw materials are based.

Learning outcomes: Training students for independent scientific and research work in the field of physical methods of concentration or continuing training in this field.

Course description:

Lectures: Introduction. Theory of the process of gravity concentration methods. Theoretical basis of stratification of grains in fluids: statistical, dynamic, kinetic. Hypotheses of stratification of grains by density: energy, hypothesis of different velocity, suspension and statistical. Theoretical consideration of separation efficiency. Fractional composition of the material by density, size and shape. Application of statistical methods of analysis in the gravity concentration methods. Mathematical interpretation of density curves. Presentation of results of the concentration by various methods. Prediction of industrial results of concentration of raw materials. The effect of probable deviation (Er) on the reliability of predetermined results. Theory of the process of magnetic methods of concentration. Phenomenology of magnetism. Magnetic properties of minerals. Magnetic properties of materials. Magnetization hysteresis and demagnetization factor. Magnetic field sources. Development of permanent magnets and superconducting materials. Theoretical analysis of magnetic concentration. Equations of movement of particles in the magnetic field of the separator. Calculation of the critical particle diameter. Modern trends in the development of devices for magnetic concentration. Eddy current magnetic separators. Analysis of forces acting on a particle in the working space of a magnetic separator with eddy currents. Theory of the process of electrical concentration methods. Electrical conductivity of conductors and semiconductors. Dielectric permeability. Electric field: homogeneous, inhomogeneous, corona discharge field. Field forces, electric forces of attraction: electrostatic and ponderomotive force. Behavior of conductors and non-conductors in an electric field. electrification of raw material grains. Separation zone of the electrical separator: forces acting on grains of different electrical conductivity in the separation zone of the separator. Modern trends in the development of electrical concentration devices. Theory of optical, radiometric and X-ray methods of concentration.

Practice: Scientific research and experimental work in the field of physical methods of concentration on mineral or secondary raw materials that are the subject of the student's study within the doctoral dissertation.

Literature:

Recommended:

1. Wills, B.A., Finch, James A. (2016). Wills' Mineral Processing Technology, An introduction to the practical aspects of ore treatment and mineral recovery (8th Edition), Butterworth-Heinemann.
2. Drzymala, J. (2017). Mineral processing. Foundations of theory and practice of minerallurgy, 2nd Edition, Ofic. Wyd. PWr, Wroclaw, Poland.
3. Svoboda, J. (2004). Magnetic techniques for the treatment of materials, Springer.
4. King, R.P. (2001). Modeling and simulation of mineral processing systems, Butterworth-Heinemann, Oxford, Great Britain.
5. Gill, C.B. (1991). Materials beneficiation, Springer-Verlag, New York.
6. Ralston, O. (1961). Electrostatic separation of mixed granular solids, Elsevier, Amsterdam.

Number of classes per week	**Lectures: 6**	**Practical classes: 4**

Teaching methods

Lectures with interactive discussions, consultations, study research work (SIR), preparation and defense of a term paper.

Knowledge evaluation (maximum 100 points)

- activity during lectures: 10 points
- SIR: 10 points
- term paper: 40 points
- oral exam: 40 points

Study program: Mining Engineering

Course: THEORY OF ELEMENTARY PHYSICAL - CHEMICAL PROCESSES IN FLOTATION

Lecturer/s: Dr Maja Trumić, Associate Professor

Status of the course: Elective subject

ECTS: 15

Prerequisite: Required knowledge in the fields of physical chemistry and theoretical principles of flotation

Course goals: Introducing students with phenomena on the interface (intermediate) relevant for flotation.

Learning outcomes: Students will be trained to develop new scientific approaches to the understanding and development of flotation as a special scientific discipline.

Course description:

Fundamental phenomena for the self-coupling of particles and bubbles and hydrodynamism of this system. Speed of air bubble flow through the liquid phase, velocity of water flow around the bubbles, thinning of the film of the liquid and analysis of the balance of forces in this system. Analysis of the forces in the three-phase system inside and on the surface of the liquid phase. Electrochemical processes on the surface of the phases and on the interface. Adsorption and adsorption isotherms. Phenomena on surfaces of materials of non-mineral origin in order to study and expand the application of flotation to new raw materials.

Literature

1. H.J.Schulze, Physico-Chemical Elementary Processes in Flotation, Elsevier, Amsterdam, 1984.
2. A.V.Nguyen, H.J.Schulze, Colloidal Science of Flotation. Marcel Dekker, 2004.
3. M.C.Fuerstenau, J.D.Miler and M.C.Kuhn, Chemistry of Flotation, SME, 1985.
4. J. Leja, Surface Chemistry of Froth Flotation, 1982
5. S.R.Rao, Surface Chemistry of Froth Flotation, Springer, 2003.
6. R.M. Pashley and .E.Karaman, Applied Colloid and Surface Chemistry, John Wiley&Sons Inc., 2004.
7. M.W.Roberts and J.M.Thomas, Chemical Physic of Solids and their Surfaces,Billing&Sons Ltd., 1980.
8. P.Somasundaran and D.Wang, Solution Chemistry: Minerals and Reagents. Elsevier, 2006.
9. Other literature of the latest publications in top-level journals in this field

Number of classes per week	Lectures: 6	Practical classes: 4

Teaching methods: Method of oral presentation and discussion, method of written work (seminar paper).

Knowledge rating (max. number of points 100)

40 % oral exam + 40 % seminar paper + 20 % defense of seminar paper

Course: THEORETICAL PRINCIPLES OF CONCENTRATION CHEMICAL METHODS

Lecturer/s: Dr Grozdanka Bogdanović, full professor

Status of the course: Elective

ECTS: 15

Prerequisite: Required knowledge in Leaching and solutions processing and Theoretical Principles of Physical-Chemical and Chemical Concentration Processes

Course goals: Introducing students with mechanism of the leaching processes, concentration and purification of metals from the solution by chemical methods. Upgrading of basic theoretical knowledge on leaching and methods of concentration of metals from solution in accordance with new knowledge in this field.

Learning outcomes: Students will be trained to study the leaching processes of minerals, waste raw materials and technogenic raw materials, as well as the chemical methods for treatment of leach solutions. They will use theoretical knowledge to develop new technologies as well as to engage in research work in these areas.

Course description:

Leaching. Physico-chemical basis of the leaching processes. Theoretical principles of leaching metal, mineral and technogenic raw materials. Kinetics and mechanism of leaching reactions. Fundamentals of concentration and purification metal ions from the solution - ion exchange, solvent extraction and adsorption/desorption. Membrane processes. Separation of metal compounds from solution: Crystallization and precipitation processes. Separation of the metal from the solution: Cementation and chemical reduction. Electrochemical separation of metals.

Literature:

1. F. Habashi, A Textbook of Hydrometallurgy, Metallurgie Extective Quebec, Enr., 1992.
2. N.Pacović, Hydrometallurgy (in Serbian) , Bor, 1980.
3. G.D.Bogdanović, M.M.Antonijević, Behavior and oxidation of chalcopyrite in an aqueous environment (in Serbian), Technical Faculty, Bor, 2011.
4. V.Stanković, Transfer phenomena and operations in metallurgy. Book 2. Heat and Mass Transfer (in Serbian), Technical Faculty, Bor, 1998 (Selected chapters)
5. Using literature from available databases (SCOPUS, SCIENCEDIRECT, WEB of SCIENCE, PROQUEST, COMPENDEX, ect.).

Number of classes per week	**Lectures: 6**	**Practical classes: 4**

Teaching methods

Method of oral presentation and discussion, method of written work (seminar work).

Knowledge evaluation (maximum 100 points)

30 % oral exam + 50 % seminar paper + 20 % defense of seminar paper

Course: TESTING OF GRINDABILITY OF MINERAL RAW MATERIALS

Lecturer/s: PhD Milan Trumić, full professor

Status of the course: Elective

ECTS: 15

Prerequisite: Necessary knowledge of comminution and classification

Course goals:

The aim of the course is to acquaint students with theoretical and practical principles and current trends in the process of testing the grindability of mineral raw materials using a modern approach and concrete examples as well as modern models in this field.

Learning outcomes:

Acquiring knowledge about methods for determining the grindability of mineral raw materials and the ability to apply that knowledge in the processes of comminution and classification various products. The acquired knowledge forms the basis for further individual training in this field.

Course description:

Lectures:

The strength of the raw material. Methods for determining grindability. Qualitative methods and relative grindability coefficient. Quantitative methods and required energy for grinding. Procedures for determining the work index in a rod mill. Procedures for determining the work index in a ball mill. Standard Bond tests and alternative abbreviated procedures for determining the work index in mills. Evaluation of Bond work index on samples of non-standard size. Effect of grinding product size on Bond work index.

Practice:

Testing of models for determining the grindability of raw materials.

Literature:

Recommended:

1. N. Magdalinović, Meljivost mineralnih sirovina, Nauka, Beograd, 1997.
2. N. Magdalinović, Energija usitnjavanja, Tehnički fakultet u Boru, 1992.
3. N. Magdalinović, Usitnjavanje i klasiranje, Nauka, Beograd, 1999.
4. N. Magdalinović, Usitnjavanje i klasiranje mineralnih sirovina-praktikum, Tehnički fakultet, Bor, 1985.
6. Barry A. Wills, Tim Napier-Munn, Mineral Processing Technology, Publisher: Elsevier Science & Technology
7. Books, Pub. Date: October, 2006.
8. Using literature from available databases (SCOPUS, SCIENCEDIRECT, WEB of SCIENCE, PROQUEST, COMPENDEX)

Number of classes per week	**Lectures: 6**	**Practical classes: 4**

Teaching methods

Classical lectures with consultant approach to independent work of students, preparation of seminar work and SIR.

Knowledge evaluation (maximum 100 points)

Exam 40 % + seminar paper 40 % + seminar work presentation 20 %

Назив предмета: CONTROLLED BLASTING

Lecturer: dr Saša S. Stojadinović, vanr. prof.

Course status: Elective

ECTS:15

Prerequisites:-

Course goal

Introducing students to new approaches to the problem of adverse effects of blasting: seismic shocks, flyrock, air shockwave , backbreak in different conditions of application of explosives

Course outcome

Ability to apply modern tools for further research in the field of prediction and prevention of negative effects of blasting

Course description

Theoretical classes

Negative effects of blasting, quantification of negative effects of blasting, impact of negative effects of blasting on the environment, risk assessment , modern approaches to the problem of negative effects of blasting, artificial neural networks as predictive and classifying tools, expert systems, methods of controlled blasting, modeling and simulation of blasting and analysis of the efficiency of applied measures.

Practical classes

Research work on a predefined topic for real conditions in the mine environment.

Recommended literature

1. S. Olofson, Applieed exsplosives technology for construction and mining, Arla, Sweden, 1988.
2. М. Савић, Минирање на површинским коповима, Институт за бакар, Бор, 2000.
3. A K Ghose, A Joshi, Blasting in Mining - New Trends, CRC Press, 2012
4. R. Holmberg, Explosives and Blasting Technique, CRC Press, 2012

Number of classes per weak	Theoretical: 6	Practise: 4

Lecture methods

Auditory lectures, consultations during the study research

Grading (maximum 100 points)

Assignment 40

Oral 60

Course: SEISMIC BLASTING

Lecturer/s: Dr Radoje Pantović, full professor

Status of the course: Elective course

ECTS: 15

Prerequisite: Necessary knowledge of blasting technology.

Course goals:

Acquaintance of students with the problem of seismic effects of blasting and methods of monitoring during blasting for the needs of mining.

Learning outcomes:

Acquiring knowledge in the field of seismic effects of blasting, influencing factors on the intensity of earthquakes, their effect on the environment, methods of measuring earthquakes, processing of measured data and standards that regulate this area.

Course description:

Lectures: Effects of explosion in boreholes. Reflection of a shock wave from a free surface. Rock mass oscillation. Energy distribution of explosives during blasting. Seismic effect. Measuring earthquakes. Seismographs, classification and basic characteristics. Field measurement procedure and operational guidelines. Seismograph accuracy, calibration. Content of seismograph records. Reading records and interpretations. Basic factors affecting earthquakes. Soil calibration. Earthquake management. Blasting in slow motion. Retardant tolerance. The concept and probability of overlap. Timing analysis of the initiation scheme. Recommendations for a reduced distance. Graph of particle velocity - reduced distance. Factors affecting earthquakes. Earthquake standards. Prolonged vibrations and fatigue. Consequences of the earthquake. The difference in the intensity of the earthquake by direction. Wavelength effects. Earthquake effects that do not cause damage. Causes of cracks and fissures that do not originate from blasting. Adjustment of blasting parameters in order to reduce the level of earthquakes. Calculations of blasting parameters near buildings. The method of making the screen. Seismic effect during blasting in underground conditions. Controlled blasting in tunnels. Blasting standards for non-residential buildings. Blasting in the vicinity of concrete structures, fresh concrete, bridges, underground lines and sensitive instruments. People's sensitivity to earthquakes. Air strikes. Instruments for measuring air overpressure, correct placement of microphones. Criterion for evaluation of aerial impact of blasting.

Practice: Demonstration exercises in the laboratory. Getting to know instruments for measuring earthquakes caused by blasting and software packages for processing and interpreting measured data.

Literature:

Recommended:

1. Kričak L. (2005): Seizmika miniranja. Rudarsko–geološki fakultet, Beograd.

2. Purtić N. (1991): Bušenje i miniranje. Rudarsko–geološki fakultet, Beograd.

Ancillary:

3. Dowding C.H. (2000): Construction Vibrations, Prentice Hall, Inc., New Jersey, USA.

4. Siskind, D. E. (2000) : Vibrations from Blasting, ISEE, Cleveland, OH, USA.

5. Lewis O.L.(1999): The effects of vibrations and environmental forces. Cleveland, OH, USA.

Number of classes per week	**Lectures: 6**	**Practical classes: 4**

Teaching methods

Lectures with interactive discussions, consultations, SIR, preparation of reports.

Knowledge evaluation (maximum 100 points)

Activity during classes and exercises 20, seminar paper 40 and exam 40.

Course: GRAVITY FLOW THEORY

Lecturer: Dr Dejan Petrović, assistant professor

Status of the course: Elective

ECTS: 15

Prerequisite: Not provided.

Course goals: Acquaintance of students with the principles of flow theory in sublevel and block caving methods.

Learning outcomes: The student's ability to make qualified decisions about the parameters and design of excavation blocks in the function of ore recovery.

Course description:

Lectures:

Gravity flow theory of blasted ore. Flow caracteristics of broken ore. Ore movement to the draw points. Kinematic of movement. Different theories of forming of elipsoide of extraction. Ellipsoid of loosening. Funnel of extraction. Ellipsoid of the same velocities. Flow velocity. Trajectory of ore flow. Influential factors on ore recovery and dilution of block caving methods. Therm of the critical, limiting and final ellipsoid of extraction. Dimension and sheape of draw ponts. Rotational ellipsoid. Triaxial ellipsoid. Calculation of the volume of a triaxial ellipsoid. Calculation of the volume of a rotational ellipsoid. Determination elipsoid parameters depending on particle size composition. Application of flow theory in sublevel and block caving methods.

Practice:

Term paper.

Literature:

Recommended:

1. Милићевић Ж., Милић В. Технологија подземне експлоатације лежишта минералних сировина, РДС група – Д.О.О., Бор, 2013.

Ancillary:

1. Literature from available databases (SCOPUS, SCIENCEDIRECT, WEB of SCIENCE, PROQUEST, COMPENDEX, etc.).

Number of classes per week	**Lectures: 6**	**Practical classes: 4**

Teaching methods

Oral lectures, calculation tasks, discussion. Term paper.

Knowledge evaluation (maximum 100 points)

Term paper 40 points, oral exam 60 points.

Course: GEOINFORMATION TECHNOLOGIES

Lecturer/s: Vušović M. Nenad

Status of the course: Elective for ELMS module students

ECTS: 15

Prerequisite: Prior knowledge of Geodesy, Geoinformatics and GIS

Course goals: Acquaintance of students with theoretical and practical knowledge in the field of Geospatial technologies: GNSS, Remote Sensing, LiDAR, Digital Photogrametry, UAV, TLS, GIS.

Learning outcomes: Acquiring knowledge Elective for ELMS module students about Reference coordinate systems and Modern techniques of data acquisition; Creation of a Spatial database; Presentation and exchange of geospatial data; Getting to know the basic GIS concepts of Spatial object modeling and Spatial data analysis

Course description:

Lectures: Spatial reference coordinate systems. Definition of reference system and reference frame. The celestial (inertial) system ICRS and its realization ICRF. International Terrestrial Reference System-ITRS and its various realizations ITRFgg. Conventional Terrestrial Reference System-TRF. International Terrestrial Reference System-ITRS. Geodetic reference system-GRS80. World Geodetic System-WGS84. Navigation (local) frames. European terrestrial reference system-ETRS89. Celestial Reference Frame-CRF. Transformation between ETRF89 and local date. Definition of geodetic dates. Conversion and transformation between coordinate systems. European vertical reference system-EVRS. United European Leveling Network-UELN. European United Vertical Networks-EUVN. Spatial reference system of Serbia. Reference network of Serbia-SREF. Active geodetic reference base of Serbia - AGROS. Horizontal reference system of Serbia. Vertical reference system of Serbia. Global navigation satellite systems-GNSS. Technological development of satellite navigation systems. Global navigation systems. Regional satellite systems. GNSS system architecture. GNSS signal structure. Basic segments of GNSS. Permanent reference networks and DGNSS services. GNSS geodetic receivers. Measurement errors. Differential GNSS. Methods of GNSS measurement and data processing. GNSS measurement accuracy standards. Modern technologies of spatial data collection. LiDAR laser scanning technology. Laser scanner. Terrestrial laser scanners-TLS. Aircraft laser scanning-ALS. Mobile laser scanning-MLS. Laser scanning of terrain and objects and data acquisition. Digital point cloud. Modeling environments from point clouds. FLI-MAP laser altimetry system. UAV-unmanned aerial vehicles. Robotic and automated recording systems. Remote Sensing. Terrestrial photogrammetry. Digital cameras. Surveying, base size and tilt, stereoscopic terrain coverage, positional accuracy, surveying design. Stereo cameras and orientation control points. Aerial photogrammetry. Orientation devices for navigation. Recording, overlapping and the required number of shots, camera selection, projection of the recording. Landmarks in aerial photogrammetry. Interpretation of aerial photogrammetric images. Radar surveying systems. Principles of functioning of radar systems. Radar with side capture-SLAR. Radar with real aperture-RAR.Radar with synthetic aperture-SAR. Geodetic technique of movement registration-InSAR. Types of radar sensors: EcoSAR, MicroASAR, DBSAR. Space radar systems. Geographic information systems-GIS. Components and functions of GIS. Modeling of spatial objects. GIS data model. Spatial database design. Internet and Web-based GIS applications. GIS tools. Spatial data infrastructure. NIGP. National Geoportal. INSPIRE directives.

Practice: Theoretical teaching is followed by practical exercises in appropriate software.

Literature:

Recommended:

1. Kraus K.: Photogrammetry: Geometry from Images and Laser Scans, Walter de Gruyter (2007)
2. McCloy K.R.: Resource Managament Information Systems Remote Sensing, GIS and Modelling, T&F (2006)
3. Shan J., Toth C.K.: Topographic Laser Ranging and Scanning: Principles and Processing, CRC Press (2008)
4. McCloy K.R: Resource Management Information Systems: Remote Sensing, GIS and Modelling, T&F (2006)
5. Kang-tsung C.: Introduction to GIS, University of Idaho, New York: McGraw-Hill Education (2018)

Ancillary:

1. Vusović N. Geoinformatics (2023) Technical Faculty in Bor. *in press*.

Number of classes per week	**Lectures: 6**	**Practical classes: 4**

Teaching methods Lectures and exercises will be held in the Center for Geoinformation Technologies and GIS, using the software: ArcGIS 10.2. and 3D Survey, supported by the service https://moodle.tfbor.bg.ac.rs

Knowledge evaluation (maximum 100 points) study research paper 20 points; written exam 30 points; oral exam 50 points.

Course: NONTRADITIONAL UNDERGROUND MINING TECHNOLOGIES

Lecturer: Dr Dejan Petrović, assistant professor

Status of the course: Elective

ECTS: 15

Prerequisite: Completed courses of underground mining technology and mining methods.

Course goals: Introduction to specific technologies of underground mining.

Learning outcomes: Individual competences for method selection, application and design in the special conditions: at great depths, under great pressure, at the bottom of the sea and ocean, etc..

Course description:

Lectures:

Scope. Properties of ore deposit under specific conditions: great depths, high pressure, at seabed, low grade ore. Drilling technologies application and physical and chemical alterations of mineral resource. Nontraditional coal mining methods: vibration – impulse, vibration, physical-chemical and microbiological coal liquefaction methods. Coal gasification. Salt and sulfur dissolving and melting methods and extraction through wells and drillholes. Gasification application in sulfur and sulfide ore mining. Oil shale extraction by underground retorting. Oil shale retorting. Fracking. Oil extraction. Hydrometallurgical ore extraction – leaching. Surface leaching and underground drillhole leaching. Preparation of leaching solutions. Bacterial leaching. Copper leaching experiences. Environmental protection measures. Underwater mining technologies. Seabed mineral exploration, equipment and mining methods. Environmental safety measures in underwater mining.

Literature:

Recommended:

1. Ž. Milićević, Metode podzemnog otkopavanja ležišta mineralnih sirovina, RdS grupa D.O.O.,Bor, 2011.
2. V. Milić, Specijalne metode eksploatacije ležišta mineralnih sirovina, Elektronsko izdanje, 2010.

Ancillary:

1. V. Milić, Ž. Milićević, Osnovi eksploatacije ležišta mineralnih sirovina, TF Bor, 2005.
2. Ž. Milićević, V. Milić, Tehnologija podzemne eksploatacije ležišta mineralnih sirovina, TF Bor, 2013.
3. Literature from available databases (SCOPUS, SCIENCEDIRECT, WEB of SCIENCE, PROQUEST, COMPENDEX, etc.).

Number of classes per week	**Lectures: 6**	**Practical classes: 4**

Teaching methods

Oral lectures, laboratory and calculus practicals, discussion.

Knowledge evaluation (maximum 100 points)

Exam 40 %, independent work 40 % and active participation during classes and study research work 20 %.

Назив предмета: SPECIFIC TECHNOLOGIES OF SURFACE MINING

Lecturer: dr Saša S. Stojadinović, vanr. prof.

Course status: Elective

ECTS:15

Prerequisites:-

Course goal

Introducing students to the specific technologies of surface mining and analysis of basic parameters.

Course outcome

The student's ability to skillfully decide on the selection and application of specific surface mining technologies and appropriate equipment.

Course description

Theoretical

Introductory remarks. Historical development, significance, condition and trends in the application of specific surface mining technologies and appropriate equipment. Basic concepts and terms. Conditions for the application of specific surface mining technologies. An overview of some specific surface mining technologies. Criteria for technology selection. Selection of specific technology. Techno-economic parameters. Rehabilitation and recultivation.

Practice

Assignment

Recommended literature

1. Н. Поповић, Научне основе пројектовања површинских копова, НИРО „Заједница“ – НИШРО „Ослобођење“, Сарајево, 1984.
2. В. Павловић, Технологија површинског откопавања, Рударско-геолошки факултет, Београд, 1992.
3. Н. Спасић, Технологија површинске експлоатације минералних сировина, Завод за уџбенике и наставна средства САП Косово, Приштина, 1979.
4. В. Павловић, Системи површинске експлоатације, Рударско-геолошки факултет, Београд, 1998.
5. А. Лазић, Пројектовање површинских копова са моделирањем система експлоатације, Рударско-геолошки факултет, Београд, 1998.
6. Р. Симић и Н. Поповић, Системи отварања и експлоатације на површинским коповима, Рударско-геолошки факултет, Београд, 1981.
7 С. Вујић, Ј. Цвејич, И. Милјановић, Д. Дражић, Пројектовање рекултивације и уређења предела површинских копова (монографија), Рударско-геолошки факултет, Београд, 2009.
8. В. Павловић, Рекултивација површинских копова и одлагалишта, Рударско-геолошки факултет, Београд, 2000.
9. Додатна литература по препоруци предавача.

Number of classes per weak	Theoretical: 6	Practise: 4

Lecture methods

Classes are conducted in the form of lectures and auditory exercises with the effort to maximally involve students, i.e. to be interactive. This is realized directly in classes or in the form of presentations, which are previously prepared by a team of students or individually. The lectures present the theoretical part of the material with constant illustration of characteristic examples from practice. The exercises analyze specific cases and give instructions regarding the preparation of the seminar paper. The assignment paper refers to some of the specific technologies of surface exploitation. Classes and exercises are intensively supported by a distance learning platform (Moodle). The engagement of students in lectures and exercises, as well as the made seminar papers are scored as pre-examination activities.

If the classes are attended by five or more students , it is directly realized, and if this number is smaller , classes are conducted mentoring.

Grading (maximum 100 points)

Assignment 40

Oral 60

Course: KINETICS OF GRINDING AND SCREENING

Lecturer/s: PhD Milan Trumić, full professor

Status of the course: Elective

ECTS: 15

Prerequisite: Necessary knowledge of comminution and classification

Course goals:

The aim of the course is to acquaint students with theoretical and empirical models of grinding kinetics in cylindrical mills. Current trends in modeling the process of grinding and screening raw materials using a modern approach and concrete examples as well as modern software in this field.

Learning outcomes:

Acquiring knowledge in the field of researching the kinetics of the process of grinding and screening raw materials and the ability to apply that knowledge in the processes of comminution and classification various products. The acquired knowledge forms the basis for further individual training in this field.

Course description:

Lectures:

Introduction. Kinetics of grinding in a mill with rods and balls. Semi-empirical models of grinding kinetics. Matrix and integral differential models of grinding kinetics. Kinetic models. Theoretical and practical value of the grinding kinetics model. A critical review of the theoretical and practical importance of certain models of grinding kinetics. Study of screening kinetics. Mathematical interpretation of screening kinetics. Stochastic and kinetic models of screening kinetics. Theoretical and practical value of screening kinetics model. A critical review of the theoretical and practical importance of certain models of screening kinetics.

Practice:

Modeling and testing of grinding and screening kinetics models.

Literature:

Recommended:

1. N. Magdalinović, I. Budić, N. Ćalić, R. Tomanec, Kinetika mlevenja, Tehnički fakultet, Bor, 1994.
2. N. Magdalinović, Meljivost mineralnih sirovina, Nauka, Beograd, 1997.
3. N. Magdalinović, Usitnjavanje i klasiranje, Nauka, Beograd, 1999.
4. N. Magdalinović, Usitnjavanje i klasiranje mineralnih sirovina-praktikum, Tehnički fakultet, Bor, 1985.
5. Mineral Processing Handbook 7/07, Telsmith, Inc., USA, 2007.
6. A.Gupta and D.S.Yan, Introduction to Mineral Processing Design and Operation, Perth, Australia, January, 2006.
7. Using literature from available databases (SCOPUS, SCIENCEDIRECT, WEB of SCIENCE, PROQUEST, COMPENDEX)

Number of classes per week	**Lectures: 6**	**Practical classes: 4**

Teaching methods

Classical lectures with consultant approach to independent work of students, preparation of seminar work and SIR.

Knowledge evaluation (maximum 100 points)

Exam 40 % + seminar paper 40 % + seminar work presentation 20 %

Study program: Mining Engineering

Course: THEORETICAL BASICS OF FLOTATION KINETICS

Lecturer/s: Dr Maja Trumić, Associate Professor

Status of the course: Elective subject

ECTS: 15

Prerequisite: Required knowledge in the fields of theoretical principles of flotation

Goal of the course: Acquaintance of students with phenomena relevant to flotation in order to model the process

Learning outcomes: Students will be able to analyze different approaches to flotation modeling and management systems.

Course description:

Lectures:

As part of the theoretical teaching in this subject, kinetics of disintegration, kinetics of adsorption, kinetics of particle adhesion to air bubbles, kinetics of levitation, kinetics of flotation, modeling flotation processes, will be studied.

Practice:

Appropriate experimental and scientific research work related to the topic of doctoral studies

Literature

1. H.J.Schulze, Physico-Chemical Elementary Processes in Flotation, Elsevier, Amsterdam, 1984.
2. A.V.Nguyen, H.J.Schulze, Colloidal Science of Flotation. Marcel Dekker, 2004.
3. J. Drzymala, Mineral Processing, Foundations of theory and practice of minerallurgy, Wroclaw University of Technology, Wroclaw 2007
4. Other literature of the latest publications in top-level journals in this field

Number of classes per week	Lectures: 6	Practical classes: 4

Teaching methods: Method of oral presentation and discussion, method of written work (seminar paper).

Knowledge rating (max. number of points 100)

40 % oral exam + 40 % seminar paper + 20 % defense of seminar paper

Course: SPECIFIC METHODS OF FLOTATION

Lecturer/s: Dr Grozdanka Bogdanović, full professor, Dr Dragan Radulović, research associate

Status of the course: Elective

ECTS: 15

Prerequisite: Acquired knowledge from courses Flotation and Theoretical Principles of Physical-Chemical and Chemical Concentration Processes

Course goals: Introducing students with theoretical and practical principles of application of flotation processes in the treatment of wastewater and diluted solutions. Upgrading of fundamental theoretical knowledge about the mechanism of development of specific flotation methods in accordance with new knowledge in this area.

Learning outcomes:

Theoretical and practical training of students for independent scientific and professional work in this field.

Course description:

Introduction. Flotation as a method for separating phases in the system solid-liquid and liquid-liquid. Theoretical principles and mechanism of specific flotation methods (ionic flotation, flotation of colloids, electro flotation, vacuum flotation, flotation with dissolved and dispersed air, bioflotation). Electrochemical processes on the surfaces of phases and interphases, adsorption and adsorption isotherms.

Literature:

1.L.K.Wang,N.K.Shammas,W.A.Selke,D.B.Aulenbach, Flotation technology, Handbook of Environmental Engineering,Volume 12, Humana Press, Springer Science, 2010.
2. S.R.Rao, Surface Chemistry of Froth Flotation, Springer, 2003.
3. R.M. Pashley and M.E.Karaman, Applied Colloid and Surface Chemistry, John Wiley&Sons Inc., 2004
4. A.W.Adamson, Physical Chemistry of Surfaces, John Wiley&Sons, Inc., 1997., ISBN 0-471-14873-3-3h.
5. Using literature from available databases (SCOPUS, SCIENCEDIRECT, WEB of SCIENCE, PROQUEST, COMPENDEX, ect.).

Number of classes per week	**Lectures: 6**	**Practical classes: 4**

Teaching methods: Method of oral presentation and discussion, method of written work (seminar work).

Knowledge evaluation (maximum 100 points)

30 % oral exam + 50 % seminar paper + 20 % defense of seminar paper

Course: ADVANCED TECHNOLOGIES FOR USING ALTERNATIVE AND RENEWABLE ENERGY SOURCES

Lecturer/s: Dr. Zoran M. Stević, full professor

Status of the course: Elective

ECTS: 15

Prerequisites: None

Course goals: Introduction the topologies of energy converters and their implementation in renewable sources. Training students to analyze and design systems to improve system performance for energy conversion from renewable sources.

Learning outcomes: Students should understand the principles of functioning of the analyzed energy sources and, based on the acquired knowledge, be able to choose an adequate topology for the given conditions.

Course description:

Lectures:

Renewable energy sources and new technologies. Solar energy. Wind Energy. Environmentally acceptable hydropower. Ecologically acceptable bioenergetics. Geothermal energy. Energetic efficiency. Accumulation of energy. Hydrogen energy and fuel cells. Distributed production of electricity. Smart grids and smart cities.

Practice:

Demonstration of the solar system. Visit to the wind farm in Kula. Visit to the Zvezdan mini-hydroelectric plant.

Literature:

1. Leon Freris, David Infi, Renewable Energy in Power Systems, A John Wiley & Sons, 2012

2. Miroslav Bjekić, Zoran Stević, Alenka Milovanović, Sanja Antić, Regulacija elektromotornih

pogona, Tehnički fakultet, Čačak (2010)

3. Sanja Bugarinović, Mirjana Rajčić-Vujasinović, Zoran Stević and Vesna Grekulović, Cuprous Oxide as an Active Material for Solar Cells, Book title: Solar Cells - New Aspects and Solutions, Edited by: Leonid A. Kosyachenko, Intech, Rijeka (2011)

4. Zoran Stević, Dubravka Nikolovski, Snežana Petrović, Zoran Nikolić, Rastislav Kragić, Stevan Šamšalović, Dragan Kovačević, Tehnika i tehnologija u funkciji zaštite životne sredine,

SMEITS, Beograd (2010)

5. Zoran Stević, Mirjana Rajčić-Vujasinović, Supercapacitors as a Power Source in Electrical Vehicles, Book title: Electric Vehicles – The Benefits and Barriers / Book 1, Edited by: Seref Soylu, Intech, Rijeka (2011)

Number of classes per week	**Lectures: 6**	**Practical classes: 4**

Teaching methods

Interactive presentations, modeling and simulations, practical teaching.

Knowledge evaluation (maximum 100 points)

Project: **40** points
Written exam: **30** points
Oral exam: **30** points

Course: Theory principles of coal processing

Lecturer/s: PhD. Jovica M. Sokolović, full professor

Status of the course: Elective for Mining Engineering

ECTS: 15

Prerequisite: Acquired knowledge at undergraduate and master's academic studies

Course goals: Study of the theoretical basis on which the coal preparation and utilisation are based.

Learning outcomes: Training students for independent scientific and research work in the field of coal preparation and utilisation or continuing training in this field.

Course description:

Lectures: Introduction. Coal: origin, basic characteristics, classification. Theoretical principles of gravity concentration of coal. Fractional composition of coal by density, size and shape. Separation efficiency and parameters of separation efficiency. Prediction of industrial results of gravity concentration of coal. Theoretical principles of operation of separators with suspensions. The efficiency of the device for gravity concentration of coal in suspensions. Theoretical principles of control of coal gravity process. Theoretical principles of magnetic concentration of coal. Magnetic properties of coal and minerals. Preparation of raw material for magnetic concentration of coal. Magnetohydrodynamic and magnetohydrostatic separation of coal. Theoretical principles of operation of magnetic separators. Contemporary trends in the development of devices for magnetic concentration of coal. Theoretical principles of electrostatic coal separation. Electrical properties and electrical conductivity of coal. Electrification (electrification) of coal and minerals. Preparation of raw material for electrostatic separation of coal. Theoretical principles of electrostatic separators operation. Recent trends in the development of devices for electric concentration of coal. Theoretical principles of coal flotation. Elementary physical-chemical processes in coal flotation. Coal flotation. The influence of oxidation on coal flotation. Pretreatment of oxidized coals. Reagents in coal flotation process. Kinetics of coal flotation. Theoretical principles of the coal desulfurization process. Chemical and bacteriological processes of coal desulfurization.

Practice: Scientific-research and experimental work in the field of application of various technologies of coal preparation and concentration, which are the subject of the student's doctoral dissertation.

Literature:

Recommended:

1. Meyers, R. A., Laskowski, J. S., Walters, A. D. (2003). Coal preparation. In R. A. Meyers (Ed.), The encyclopedia of physical science and technology (pp. 79–106). San Diego: Academic Press.
2. Lynch, A.J., Johnson, N.W., Manlapig, E.V., Thorn, C.G. (1981). Mineral and coal flotation circuits—their simulation and control. Elsevier, Amsterdam, Netherland.
3. Svoboda, J. (2004). Magnetic techniques for the treatment of materials, Springer.
4. Ralston, O. (1961). Electrostatic separation of mixed granular solids, Elsevier, Amsterdam.

Number of classes per week	**Lectures: 6**	**Practical classes: 4**

Teaching methods

Lectures with interactive discussions, consultations, study research work (SIR), preparation and defense of a term paper.

Knowledge evaluation (maximum 100 points)

- activity during lectures: 10 points
- SIR: 10 points
- term paper: 40 points
- oral exam: 40 points

Course: Microscopic examinations in preparation and concentration processes

Lecturer/s: PhD Zoran Štirbanović, associate professor

Status of the course: Elective for Mining Engineering

ECTS: 15

Prerequisite: none

Course goals: Introducing students with the theoretical foundations of ore microscopy and its practical application in the processes of preparation and concentration of mineral and secondary raw materials.

Learning outcomes: Training students for the application of ore microscopy in the processes of preparation and concentration of mineral and secondary raw materials, as well as the analysis of the obtained results in order to improve the technological indicators of the process.

Course description:

Lectures:

Ore microscopy. Principles of operation of ore microscopes. Identification of minerals using an ore microscope. Microscopic analyses. Qualitative analysis of samples. Quantitative analysis of samples. Ways of occurrence of minerals. Determination of structural and textural characteristics of mineral grains. Shape and size of mineral grains. Liberation of mineral grains. Liberation of minerals in the preparation and concentration processes. Analysis of the impact of liberation. Microscopic analysis in the comminution processes. Microscopic analysis in classification processes. Microscopic analysis in concentration processes. Other microscopic methods and their application in preparation and concentration processes. Application of microscopy in the processes of preparation and concentration of secondary raw materials.

Practice:

The practical work includes the study of the practical applicability of ore microscopy in the processes of preparation and concentration of mineral and secondary raw materials, as well as the analysis of the influence of various parameters of the raw material on the technological indicators of the process.

Literature:

Recommended:

1. A. Pačevski, Ore Microscopy, Faculty of Mining and Geology, Belgrade, 2018. (*In Serbian*)
2. R. Tomanec, B. Vakanjac, Ore paragenesis with testing methods and a list of characteristic examples, Futura, Belgrade, 2015. (*In Serbian*)
3. B. Herman, J. J. Lemasters, Optical Microscopy: Emerging Methods and Applications, Academic press, Inc. San Diego, California, 1993.
4. P.W. Hawkes, J.C.H. Spence, Science of Microscopy; Volume 1, Springer Science+Business Media, 2007.
5. W. J. Croft, Under the Microscope: A Brief History of Microscopy, World Scientific, 2006.
6. Current literature, as recommended by the teacher.

Number of classes per week	**Lectures: 6**	**Practical classes: 4**

Teaching methods

The lectues are organized on an interactive principle, which includes discussion and analysis of the possibility of applying microscopic analysis in the preparation and concentration processes, as well as practical work on the ore microscope. Preparation of a term paper is also planned.

Knowledge evaluation (maximum 100 points)

Activity during leactures - **20** points
Term paper - **30** points
Oral exam - **50** points

Course: Multi-criteria decision making in preparation and concentration processes

Lecturer/s: PhD Zoran Štirbanović, associate professor; PhD Dragiša Stanujkić, full professor

Status of the course: Elective for Mining Engineering

ECTS: 15

Prerequisite: none

Course goals: Introducing students to the theoretical foundations of multi-criteria decision-making methods and their application in the preparation and concentration processes.

Learning outcomes: Training students for the application of multi-criteria decision-making methods with a special focus on the specifics of application in the processes of preparation and concentration of mineral and secondary raw materials

Course description:

Lectures:

Decision theory. Multi-criteria decision-making. Basic elements of multi-criteria decision-making.

Selected methods of multi-criteria decision-making; SAW, AHP, TOPSIS, VIKOR, ELECTRE, PROMETHEE, MULTIMOORA, SWARA, etc.

New approaches in dealing with uncertainty: Fuzzy logic and fuzzy sets. Linguistic aspects of fuzzy logic, fuzzification and de-fuzzification. Gray sets. Rough sets. Interval-valued and intuitionistic fuzzy sets. Neutrosophic sets. Group decision making.

Some extensions of classical methods of multi-criteria decision-making.

Application of multi-criteria decision-making methods in preparation and concentration processes

Practice:

Practical work includes the study of relevant achievements in the respective field, and the formation of an appropriate critical review of their applicability and significance. Through practical work, the applicability of multi-criteria decision-making in the processes of preparation and concentration of mineral and secondary raw materials will be analyzed on various practical examples, as well as on case studies.

Literature:

Recommended:

1. D. Pavličić, Theory of decision-making, Center for publishing activities of the Faculty of Economics, Belgrade, 2014. (*In Serbian*)
2. M. Čupić, V. M. Rao Tummala, M. Suknović, Decision Making: A Formal Approach, Faculty of Organizational Sciences, Belgrade, 2003. (*In Serbian*)
3. G. Ćirović, D. Plamenac, Rough sets: application in construction, Society of Operational Researchers, Belgrade, 2005. (*In Serbian*)
4. S. Vujić, I. Miljanović, Fazi logic in mining, Monograph, Academy of Engineering Sciences Serbia, Mining Institute, Belgrade, 2013. (*In Serbian*)
5. D. Bouyssou, T. Marchant, M. Pirlot, A. Tsou kias, P. Vincke, Evaluation and decision models with multiple criteria: Stepping stones for the analyst, Springer Science+Business Media, Inc., USA, 2006.
6. J. Figueira, S. Greco, M. Ehrgott, MULTIPLE CRITERIA DECISION ANALYSIS: STATE OF THE ART SURVEYS, Springer Science+Business Media, Inc., Boston, USA, 2005.
7. I. Kaliszewski, Soft Computing For Complex Multiple Criteria Decision Making, Springer Science+Business Media, Inc., USA, 2006.
8. Y. Bai, H. Zhuang, D. Wang, (Eds.) Advanced Fuzzy Logic Technologies in Industrial Applications, Springer-Verlag London Limited, 2006.
9. C. Kahraman, (Ed.) Fuzzy Applications in Industrial Engineering, Springer-Verlag Berlin Heidelberg, 2006.
10. Current literature, as recommended by the teacher.

Number of classes per week	**Lectures: 6**	**Practical classes: 4**

Teaching methods

Lectures are organized on an interactive principle, which implies discussion and analysis of various practical examples, as well as case studies. Preparation of a seminar paper is also planned.

Knowledge evaluation (maximum 100 points)

Activity during leactures - **20** points
Term paper - **30** points
Oral exam - **50** points

Course: Methodology of scientific research

Lecturer/s: dr. Mira Cocić, full professor

Status of the course: Compulsory for Mining Engineering

ECTS: 20

Prerequisite: Acquired knowledge from Undergraduate and Master studies

Course goals: Mastering of basic knowledge of methods of scientific research and research techniques in order to implement scientific approach and enable independent and team presentation of the scientific results

Learning outcomes: Theoretical and practical training for work in scientific institutions, which study mining

Course description:

Lectures: Methodology of scientific research. Basic scientific terms: subject of studies, structure of studies, phases of acquiring scientific knowledge, classification of science. General scientific methods: observation, experimental, classification. Methods of analogy. Universal scientific methods: analysis and synthesis. Current methods of technical-technological sciences: mathematical and statistical methods. Phases of methodological processes (research question, theory, data, data usage, research as a cycle). Validity and reliability of measurement. Basic technology used in scientific research. Selection of the subject. Collecting, analyzing and ordering of research materials. Writing of scientific thesis. Specific of scientific research in mining.

Practice:

Literature:

Recommended:

1. M. Vojinović, D. Milanović, Methodology of scientific research, MGF, Belgrade, 1998.
2. G. Zaječaranović, Basics of scientific methodology, Naučna knjiga, 1987.
3. M. Vuković, Ž. Živković, Methodology of scientific research, Grafožig, Belgrade, 2005.

Ancillary:

1. N. Vušović, Methodology of scientific research in mining, Grafomed-trade, Bor, 2010.

Number of classes per week	**Lectures: 6**	**Practical classes: 4**

Teaching methods

Oral presentation, study research work

Knowledge evaluation (maximum 100 points)

Exam 40%, term paper 40% and activity during classes and study research work 20%.

Study program: Technological Engineering

Level of study: Doctoral Academic Studies

Subject: FUNDAMENTAL OF SOIL REMEDIATION

Lecturer: PhD Grozdanka Bogdanović, full professor PhD Ana Simonović, assistant professor

Status of the subject: Elective subject for the Technological Engineering and Mining Engineering

ECTS: 20

Precondition: Required knowledge in the field of pollution and soil protection.

Goal of the subject: Acquaintance of students with the chemistry of solutions, the interaction of pollutants with soil components and methods of purification of polluted soil. The program will enable students to independently examine the soil and propose appropriate methods of eliminating pollutants.

Outcome of the subject: Students will be trained for independent scientific and professional work in this field.

Contents of the subject:

Soil chemistry. Soil analysis. Solubility of soil components. Carbonate balance. Reactions of ion exchange in soil. Adsorption processes. Acid-base balance. Redox processes in soil. Inorganic and organic pollutants. Interaction of pollutants with soil components. Remedial technologies. Bioremediation. Chemical oxidation. Thermal desorption. Electrokinetic remediation. Soil washing. Extractive methods of soil purification. Calcification and reduction of salinity. Phytoremediation. Extraction of heavy metals. Other purification techniques.

Literature

1.R.G. Buran and R.J. Zasoski, Soil and water shemistry, U.C. Davis, 2002

2. Rebecca Burt, Soil Survey Laboratory Methods Manual, NRCS, USA 2004,

3. Margesin Rosa, Schinner Franz, Manual for Soil Analysis: Monitoring and Assessing Soil Bioremediation, Berlin, New York Springer Science & Business Media, 2005.

4. Lavelle, P. Spain, Alister V., Soil Ecology, Boston Kluwer Academic Publishers, 2001.

5. Calabrese Edward J.; Kostecki Paul T.; Dragun James, Contaminated Soils, Sediments and Water: Science in the Real World, New York Kluwer Academic Publishers, 2005,

6. Breemen N. van.; Buurman P, Soil Formation, Boston Kluwer Academic Publishers, 2002,

7. Коришћење литературе из доступних база података (SCOPUS, SCIENCEDIRECT, WEB of SCIENCE, PROQUEST, COMPENDEX, etc.).

Number of classes per week	Lectures: 6	Study research: 4

Methods of teaching: Method of oral presentation and discussion, method of written work (term paper).

Knowledge rating (max. number of points 100)

Oral exam 30% + preparation of term paper 50% + defense of term paper 20%

Course: INTELLIGENT CONTROL SYSTEMS

Lecturer/s: Dr. Dejan I. Tanikić, associate professor, Dr. Zoran M. Stević, full professor

Status of the course: Elective

ECTS: 20

Prerequisites: None

Course goals: Introduction to intelligent systems and basic techniques used for designing such systems.

Learning outcomes: Student has acquired theoretical knowledge about the intelligent systems and can apply these systems in support of the control and the decision making processes

Course description:

Lectures:

The basic concept of the artificial intelligence based systems. Characteristics of the intelligent systems. Knowledge representation and ways of drawing conclusions. Knowledge acquisition and learning methods. Using existing databases. Soft computing techniques. Artificial neural networks. Types of the artificial neural networks. Activation functions and learning algorithms. Fuzzy systems. Methods of the fuzzification of the input variables. Ways of inferencing and de-fuzzification. Hybrid neuro-fuzzy systems. Genetic algorithms. Principles of functioning of the genetic algorithms. Integration of the various soft computing techniques in hybrid systems. Using the intelligent systems for solving specific engineering problems.

Practice:

Practical application of the obtained knowledge in accordance with the listed thematic topics.

Literature:

1. Dejan Tanikić, Veštačke neuronske mreže, fazi logika i genetski algoritmi, Univerzitet u Beogradu, Tehnički fakultet u Boru, 2016.

2. Z. Miljković, Sistemi veštačkih neuronskih mreža u proizvodnim tehnologijama, Mašinski fakultet Beograd, 2004.

3. P. Subašić, Fazi logika i neuronske mreže, Tehnička knjiga, Beograd, 1997.

4. W. Pedrycz, Computational Intelligence: An Introduction, CRC Press, 1998.

5. L. C. Jain, N. M. Martin, Fusion of Neural Networks, Fuzzy Systems and Genetic Algorithms: Industrial Applications, CRC Press, 1998.

6. Neural Networks: Algorithms, Applications, and Programming Techniques, Addison-Wesley Publishing Company, Inc., 1991.

Number of classes per week	**Lectures: 6**	**Practical classes: 4**

Teaching methods

Lectures, independent research work

Knowledge evaluation (maximum 100 points)

- activity during the lecture: **10** points
- practical teaching: **10** points
- term paper: **30** points
- oral exam: **50** points

Study program: Mining Engineering

Level of study: Doctoral Academic Studies

Course: MACHINE LEARNING

Lecturer: Dr Dejan Tanikić, full professor

Course status: Elective course

ECTS: 20

Prerequisites: Basic knowledge in statistics and probability theory

Course goals:

Introduction to basic concepts of machine learning and realization of the intelligent computer systems that have the ability to learn from the prior experience. Effective collecting, manipulating and management of the process data and intelligent data analysis.

Learning outcomes:

Student has acquired knowledge and skills for using mathematical tools as well as modern software tools in solving of the specific engineering problems supported by the machine learning methods.

Course description:

Theoretical teaching: The basic concepts. Learning aspects. Analytical learning. Inductive learning – learning based on examples. Parametric and non-parametric models. Generative and discriminatory models. Deterministic and probabilistic models. Supervised machine learning. Classification problem. Regression problem. Unsupervised machine learning. Clustering. Semi-supervised machine learning. Machine learnig model evaluation. Bayesian decision theory. Decision trees. Support vector machine (SVM). Linear regression. Logistic regression. K-nearest neighbor (kNN) algorithm. Artificial neural networks.

Practical teaching: Practicals. Other forms of teaching.

Practical application of the obtained knowledge in accordance with the listed thematic topics.

Literature:

1. A. Smola, S. V. N. Vishwanathan, Introduction to Machine Learning, Cambridge University Press, 2008.
2. S. Russell, P. Norvig, Artificial Intelligence: A Modern Approach, 3rd edition, Prentice Hall, 2010.

Number of classes per week:				**Other classes:**
Lectures: 6	Practicals: 4	Other forms of teaching:	Study research work:	

Methods of teaching:

Lectures, practicals, practical tasks.

Grading system (max. number of points 100)

Pre-examination requirements	**Number of points**	**Final examination**	**Number of points**
Attendance	10	Written exam	
Activity during practicals	10	Oral exam	50
Practical tasks	30		

Course: Selected Chapters From Mathematics

Lecturer/s: Ivana Z. Đolović

Status of the course: Elective

ECTS: 15

Prerequisite: Fundamental knowledge in statistics and mathematics

Course goals: Students should be able to use appropriate mathematical and statistical concepts and tools in recognizing and solving problems

Learning outcomes: Students should be able to apply theoretical knowledge from statistics in recognizing and solving tasks in further studying process as well as real problems in engineering, sciences, business and technology fields

Course description:

Selected topics from mathematical analysis: Real-Valued Functions of Several Variables; Multiple integrals;

Selected topics from numerical analysis: Errors; Representation of Numbers, Interpolation and Approximation

Selected topics from probability and statistics: Random event. Discrete and continuous random variables and most important distributions; the probability density function; expected value and variance; Statistical data, frequency distribution, mean values; measures of dispersion; coefficient of skewness; Pearson's moment coefficient of kurtosis (excess kurtosis); Population and sample; Confidence intervals; Hypothesis tests (selected parametric and non-parametric tests); Regression analysis(linear regression; nonlinear regression; multiple regression)

Literature:

Recommended:

1. I.Đolović, Statistika, Univerzitet u Beogradu, Tehnički fakultet u Boru, Bor, 2016.
2. S.Vukadinović, J.Popović, Matematička statistika, Saobraćajni fakultet, 2004.
3. Lj.Petković, Numerička matematika, Gradina Niš, 1994.
4. G.Milovanović, Numerička analiza II, Naučna knjiga, Beograd, 1991.
5. Z.Ivković, Matematička statistika, Naučna knjiga, Beograd, 1976.
6. S.Vukadinović, D.Sučević, Z.Šami, Matematika II sa zbirkom zadataka, Saobraćajni fakultet, 2003.

Remark: All sources and literature which cover selected topics are welcome

Number of classes per week	**Lectures: 6+4**	**Other forms of teaching: /**

Frontal teaching for theoretical knowledge and group, individual and combined learning in practical parts of lessons (students engagement through active learning – applications and discussions)

Knowledge evaluation (maximum 100 points)

Written part of the final exam: **30**	Oral part of the final exam: **30**	Term paper: **40**

Course: EXPERT SYSTEMS IN MINING

Lecturer: Dr Dejan Petrović, assistant professor

Status of the course: Elective

ECTS: 20

Prerequisite: Acquaintance basics statistical terms

Course goals: Theoretical basis for further application in practice and other scientific fields.

Learning outcomes: Students' ability to recognize and apply the knowledge and methods acquired within this subject in other scientific disciplines and shown and realized through independent work on a specific problem.

Course description:

Lectures:

General about natural and artificial intelligence. Knowledge and reasoning. Architecture of expert systems. Expert systems based on mathematical logic. Fuzzy expert systems. Fuzzy number and fuzzy sets theory, linear arrangement of fuzzy numbers, fuzzy logic and fuzzy systems modeling. Fuzzy process control, design and implementation examples, non-linear analysis, identification and assessment, further directions of application of fuzzy theory. Hardware and software implementation of fuzzy systems, application of fuzzy systems in system identification, decision-making. Neural networks. Basic artificial neural networks. Training of neural networks. Application of artificial neural network in automatic control systems, identification of nonlinear dynamic systems using neural networks, application of neural networks for intelligent sensors, neuro controller design. Programming of fuzzy systems and neural networks. Analysis of the designed solution. Projecting management structures. Some practical considerations and design examples. Genetic algorithms. Modern intelligent systems. Construction of expert systems.

Practice:

Term paper.

Literature:

Recommended:

1. Полишчук Ј. Експертски системи, ЕТФ, Подгорица, 2004
2. Субашић П. Фази логика и неуронске мреже, Техничка књига, Београд, 1997.
3. Siler W., Buckley J. Fuzzy expert systems and reasoning, John Wiley & Sons, Hoboken, New Jersey, 2005.
4. Literature from available databases (SCOPUS, SCIENCEDIRECT, WEB of SCIENCE, PROQUEST, COMPENDEX, etc.).

Number of classes per week	**Lectures: 6**	**Practical classes: 4**

Teaching methods

Oral lectures, calculation tasks, discussion. Term paper.

Knowledge evaluation (maximum 100 points)

Term paper 40 points, oral exam 60 points.

Study program: Mining Engineering		
Level of study: Doctoral Academic Studies		
Subject: DOCTORAL DISSERTATION – DEFINING THEME		
Lecturer: All professors from study program, eligible to be a mentor		
Status of the subject: Obligatory subject		
ECTS: 10		
Precondition: All exams at the PhD level successfully passed		
Goal of the subject: Applying new theoretically – methodological, scientific and vocational applicable knowledge, methodology and contemporary methods, available in the SCI listed journals, in solving concrete tasks in frame of the PhD level subjects.		
Outcome of the subject: The student will be trained to become capable to carry on analysis and synthesis of the doctoral level subject level, on his/her own. Also, to apply gained knowledge in structuring the research problem and defining the potential directions of its solution. Independent application of the literature resources from the available data bases with the purpose of complete overview of the predefined research problem.		
Contents of the subject: The course content is to be prepared for each student individually, in line with requirements of his/her future work. Student will review scientific literature aiming the solution of concrete research task, through: a) defining the methodology of research that will be applied in the work on the doctoral thesis (dissertation), b) clearly defined basic scientific contributions that will result from the doctoral thesis, The work on above tasks will result with written report – seminar work, that will be defended in front of the three members commission, appointed through Scientific-educational council of Technical faculty in Bor. The members of the commission will be initially proposed at the departments level.		
Literature Available scientific journal and book publications from the „Kobson" list, as well as available library literature.		
Number of classes per week	Lectures: 0	Study research work: 10
Methods of teaching Mentor is assigning the research task, in consultations with the student, for defining the research elaborate, which will present the scientific validation of the proposed doctoral dissertation theme. Preliminary literature is to be defined by the mentor. All further research of available literature resources will be completed by the student. During students work on the final elaborate, the mentor can be involved with adequate suggestions and instructions that will result with high quality of explanation of the scientific contribution and adequacy of selected theme of the dissertation. During his/her work on the elaborate, student shell conduct all necessary experiments, measurements, analysis and other research work, with the aim to define and explain the research problem, as better as possible. After defending the elaborate, mentor will start the procedure for official acceptance of the doctoral dissertation theme.		
Knowledge evaluation (maximum 100 points) Seminar paper: 50, Oral exam: 50		

Study program: Mining Engineering		
Level of study: Doctoral Academic Studies		
Subject: DOCTORAL DISSERTATION – RESEARCH WORK 1		
Lecturer: All professors from study program, eligible to be a mentor		
Status of the subject: Obligatory subject		
ECTS: 30		
Precondition: All exams at the PhD level successfully passed		
Goal of the subject: Applying basic theoretically – methodological, scientific and vocational applicable knowledge, methodology and contemporary methods, available in the SCI listed journals, in solving concrete tasks in frame of the subject of the doctoral dissertation. Through defined theme of the doctoral dissertation student study the problem, its structure and complexity, conducts analysis and synthesis and defines the potential directions for its solution. The goal of students activities, at this study level is in acquiring of necessary experience for independent structuring of the research problem and finding the solutions for solving it.		
Outcome of the subject: The student will be trained to become capable to practically apply the knowledge generated through the subjects of this study program and use it in solving the defined practical problem. Through independent application of the literature resources from the available data bases, student will expand his/her knowledge and will become capable in using the contemporary methods and tools in solving the predefined research problems.		
Contents of the subject: The course content is to be prepared for each student individually, in line with requirements of his/her future work. Student will review scientific literature and conduct necessary research work, which are connected with the subject of the doctoral thesis theme (laboratory research, field work research, etc.).		
Literature Available scientific journal and book publications from the „Kobson“ list, as well as available library literature.		
Number of classes per week	Lectures: 0	Study research work: 20
Methods of teaching Mentor is assigning the research task, with proposition of main research directions, that resulted from the defined and defended research elaborate, during the definition of the doctoral dissertation theme course. During students work on the doctoral thesis, the mentor can be involved with adequate suggestions and instructions that will result with high quality of final content of the doctoral dissertation.		
Knowledge evaluation (maximum 100 points) Seminar paper: 50, Oral exam: 50		

Study program: Mining Engineering		
Level of study: Doctoral Academic Studies		
Subject: DOCTORAL DISSERTATION – RESEARCH WORK 2		
Lecturer: All professors from study program, eligible to be a mentor		
Status of the subject: Obligatory subject		
ECTS: 30		
Precondition: All exams at the PhD level successfully passed		
Goal of the subject: Applying basic theoretically – methodological, scientific and vocational applicable knowledge, methodology and contemporary methods, available in the SCI listed journals, in solving concrete tasks in frame of the subject of the doctoral dissertation. Through defined theme of the doctoral dissertation student study the problem, its structure and complexity, conducts analysis and synthesis and defines the potential directions for its solution. The goal of students activities, at this study level is in acquiring of necessary experience for independent structuring of the research problem and finding the solutions for solving it.		
Outcome of the subject: The student will be trained to become capable to practically apply the knowledge generated through the subjects of this study program and use it in solving the defined practical problem. Through independent application of the literature resources from the available data bases, student will expand his/her knowledge and will become capable in using the contemporary methods and tools in solving the predefined research problems.		
Contents of the subject: The course content is to be prepared for each student individually, in line with requirements of his/her future work. Student will review scientific literature and conduct necessary research work, which are connected with the subject of the doctoral thesis theme (laboratory research, field work research, etc.).		
Literature Available scientific journal and book publications from the „Kobson“ list, as well as available library literature.		
Number of classes per week	Lectures: 0	Study research work: 20
Methods of teaching Mentor is assigning the research task, with proposition of main research directions, that resulted from the defined and defended research elaborate, during the definition of the doctoral dissertation theme course. During students work on the doctoral thesis, the mentor can be involved with adequate suggestions and instructions that will result with high quality of final content of the doctoral dissertation.		
Knowledge evaluation (maximum 100 points) Seminar paper: 50, Oral exam: 50		

Study program: Mining Engineering

Level of study: Doctoral Academic Studies

Subject: DOCTORAL DISSERTATION – RESEARCH WORK 3

Lecturer: All professors from study program, eligible to be a mentor

Status of the subject: Obligatory subject

ECTS: 30

Precondition: All exams at the PhD level successfully passed

Goal of the subject:

Applying basic theoretically – methodological, scientific and vocational applicable knowledge, methodology and contemporary methods, available in the SCI listed journals, in solving concrete tasks in frame of the subject of the doctoral dissertation.

Through defined theme of the doctoral dissertation student study the problem, its structure and complexity, conducts analysis and synthesis and defines the potential directions for its solution. The goal of students activities, at this study level is in acquiring of necessary experience for independent structuring of the research problem and finding the solutions for solving it.

Outcome of the subject:

The student will be trained to become capable to practically apply the knowledge generated through the subjects of this study program and use it in solving the defined practical problem. Through independent application of the literature resources from the available data bases, student will expand his/her knowledge and will become capable in using the contemporary methods and tools in solving the predefined research problems.

Contents of the subject:

The course content is to be prepared for each student individually, in line with requirements of his/her future work. Student will review scientific literature and conduct necessary research work, which are connected with the subject of the doctoral thesis theme (laboratory research, field work research, etc.).

Literature

Available scientific journal and book publications from the „Kobson“ list, as well as available library literature.

Number of classes per week	Lectures: 0	Study research work: 20

Methods of teaching

Mentor is assigning the research task, with proposition of main research directions, that resulted from the defined and defended research elaborate, during the definition of the doctoral dissertation theme course. During students work on the doctoral thesis, the mentor can be involved with adequate suggestions and instructions that will result with high quality of final content of the doctoral dissertation.

Knowledge evaluation (maximum 100 points)

Seminar paper: 50, Oral exam: 50

Study program: Mining Engineering		
Level of study: Doctoral Academic Studies		
Subject: DOCTORAL DISSERTATION – REALIZATION AND DEFENSE OF THESIS		
Lecturer: All professors from study program, eligible to be a mentor		
Status of the subject: Obligatory subject		
ECTS: 25		
Precondition: All exams at the PhD level successfully passed		
Goal of the subject: Successful defending the doctoral thesis of the student.		
Outcome of the subject: After successfully and independently completing and writing a doctoral dissertation in the field chosen for when enrolling in doctoral studies, the candidate acquires the right to proceed to the defense of the doctoral dissertation.		
Contents of the subject: The student chooses a topic for his doctoral dissertation from the areas covered by the elective courses. The doctoral dissertation should contain the usual chapters: Title, Introduction, Literature Review, Working Hypothesis and Research Objective, Research Methods, Results, Discussion, Conclusion and References.		
Literature All available domestic and foreign literature related to the scientific field from which the doctoral dissertation was submitted.		
Number of classes per week	Number of classes per week	Number of classes per week
Methods of teaching Analysis of experimental data obtained by the methods used and processing of the results, as well as writing a dissertation, in consultation with the mentor and members of the Commission..		
Knowledge evaluation (maximum 100 points)		
Research, writing doctoral dissertation	50	
Presentation and defense of doctoral dissertation	50	