BOOK OF COURSES

STUDY PROGRAM:

MINING ENGINEERING

DOCTORAL ACADEMIC STUDIES

(LEVEL III OF STUDIES)

BOR, 2013.

Content – List of courses

1. METHODOLOGY OF SCIENTIFIC RESEARCH

Content

Study program: Mining Engineering		
Level of study: Doctoral Academic Studies		
Course: METHODOLOGY OF SCIENTIFIC RESEARCH		
Lecturer: Dr Mira Cocić, associate professor; Dr Milan Trumić, full professor		
Course status: Elective course		
ECTS: 15		
Prerequisites: Acquired knowledge at 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 where mining is studied.		
Course description: ***Theoretical part****:* Methodology of scientific research. Basic scientific terms: course 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 course. Collecting, analyzing and ordering of research materials. Writing a scientific thesis. Specific scientific research in mining.		
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. **Supplementary:** 1. N. Vušović, Methodology of scientific research in mining, Grafomed-trade, Bor, 2010.		
Number of classes per week	Lectures: 6	Study research work: 4
Methods of teaching Oral presentation, study research work		
Grading system (max. number of points 100)		
Exam 40 %, independent work 40 % and activity during classes and study research work 20 %.		

2. NUMERICAL METHODS IN GEOMECHANICS

Content

Study program: Mining Engineering		
Level of study: Doctoral Academic Studies		
Course: NUMERICAL METHODS IN GEOMECHANICS		
Lecturer: Dr Radoje Pantović, full professor		
Course status: Elective course		
ECTS: 15		
Prerequisites: 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: ***Theory***: 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. ***Study and research***: 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. **Supplementary:** 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 weak:	Lectures: 6	Study research work: 4
Methods of Teaching: Oral lectures, laboratory and calculus practicals, discussion		
Grading system (maximum number of points 100)		
Exam 40 %, independent work 40 % and activity during classes and study research work 20 %.		

3. THEORETICAL PRINCIPLES OF COMMINUTION AND CLASSIFICATION Content

Study program: Mining Engineering		
Level of study: Doctoral Academic Studies		
Course: THEORETICAL PRINCIPLES OF COMMINUTION AND CLASSIFICATION		
Lecturer: Dr Milan Trumić, full professor		
Course status: Elective course		
ECTS: 15		
Prerequisites: Knowledge acquired at comminution and classification of materials courses		
Course goals: Introduction to theoretical and fundamental principles on which comminution and classification are based, using a 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: ***Theoretical teaching****:* 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	Study research work: 4
Methods of teaching: Traditional lectures with a consultative approach to students working independantly, the preparation of seminar paper and study research work.		
Grading system (max. number of points 100) 40 % oral exam +40 % seminar paper + 20 % defense of seminar paper		

4. MICRONIZATION, MECHANICAL AND MECHANOCHEMICAL ACTIVATION OF MINERALS

Content

Study program: Mining Engineering		
Level of study: Doctoral Academic Studies		
Course: MICRONIZATION, MECHANICAL AND MECHANOCHEMICAL ACTIVATION OF MINERALS		
Lecturer: Dr Milan Trumić, full professor; Dr Ljubiša D. Andric, full professor		
Course status: Elective course		
ESPB Number: 15		
Prerequisites: Knowledge of comminution and classification is required		
Course goals: Introduction to 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 this 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 the 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: **Recommended:** 1. V.I.Molchanov, T.S. Yosupov, "Physical and chemical properties of tonic-dispersed minerals", Nedra, Moscow, 1981. 2. Gerhard Heineke, Hans Peter Henning, Eberhard Linke, Ursula Steinike, Peter Adolf Thiessen: Tribochemistry, Akademie-Verlag-Berlin, 1984. 3. V.I. Molčanov, O.G. Selezneva, E.H. Zirnov: " Activation of Minerals in milling ", Nedra, Moscow, 1988. 4. K. Tkáčová: "Mechanical Activation of Minerals", ELSEVIER, 1989. 5. Nedeljko Magdalinović: " Crushing Energy ", University of Belgrade, Technical Faculty Bor, 1992. 6. Momčilo M. Ristic: "Principles of material science", Belgrade, 1993. 7. P. Baláž, Slovak Academy of Sciences, Košice, Slovakia: "Mechanochemistry in Nanoscience and Minerals Engineering", ISBN 978-3-540-74854-0, Springer, 2008.		
Number of classes per week:	Lectures:	Study research work: 4
Methods of teaching: Traditional lectures with a consultative approach to students working independantly, the preparation of seminar paper and SIR.		
Grading system (max. number of points 100) Exam 40 % + seminar paper 40 % + seminar paper presentation 20 %.		

5. DESIGN OF GEOINFORMATION SYSTEMS

Content

Study program: Mining Engineering		
Level of study: Doctoral Academic Studies		
Course: DESIGN OF GEOINFORMATION SYSTEMS		
Lecturer: Dr Nenad Vušović, full proffesor		
Course status: Elective course		
ECTS: 6		
Prerequisites: Acquired IT knowledge at Geoinformatics and Geobase data courses		
Course goals: Introduction to the principles and functions of geoinformation systems, specificities of designing GIS and spatial databases		
Learning outcomes: The skill of using ArcGIS software, creating GIS solutions and implementing GIS		
Course description: Definitions of GIS. History, development and application of GIS. Main components of GIS. Key functions of GIS. GIS development phases. Development of project GIS documentation. Collecting, verifying and displaying spatial data. Spatial data models and axioms (conceptual models of real-world geophenomics, conceptual space models, geodatabase models, axioms and data manipulation methods, data modeling). Spatial data in a computer (encoding, structures, organization, access to geocodes). Vector and raster data. Raster data model. Vector data model. Coordinate systems and projections in GIS software packages. Designing spatial databases (elements, objects, object types, attributes, layers). Linking graphic and alphanumeric data to GIS. Preparation, organization and visualization of data in GIS. Attributing and symbolizing graphic data. Standardization of geopaths. The basics of using geoinformatics software and professional applications (ArcGIS). Presentation of analysis results (visualization of spatial data, cartographic display, 3D display). Analysis of discrete entities in space. Spatial analysis using continuous fields. Applications of GIS technology in mining and geology. GIS-based web. ***Practical classes*:** work on a computer in GIS software and seminar paper		
Literature: **Recommended:** 1. B. Bajat. D. Blagojević, Principles of GIS, Geocart, Belgrade, 2007. 2. D. Mihailović, Basics of Geoinformatics, Faculty of Civil Engineering, Belgrade, 2006. 3. B. Bajat. D. Blagojević, Transmission of errors in GIS modeling of the environment, Geokarta, Belgrade, 2007. 4. N. Vušović, Database, University at Belgrade-Technical faculty in Bor, 2009. 5. N. Vušović, Geoinformatics and geobase data- Authorized lectures, University at Belgrade-Technical faculty in Bor, 2013. 6. N. Vušović,, Geoinformation technologies- Authorized lectures, University at Belgrade-Technical faculty in Bor, 2013. 7. ESRI training and education http://training.esri.com/gateway/index.cfm. **Supplementary:** 1. Keith C. Clarke, Geographic Information Systems, University of California, Santa Barbara, 2005. 2. Karen R.M.Stewart, The Marriage of CAD and GIS, AEC-Science & Technology, Corporate Information Services Township of Langley, B. Columbia, Canada, 2005.		
Number of classes per week:	Lectures: 6	Study research work: 4
Methods of teaching: ESRI training		
Grading system (max. number of points 100)		
Exam 40 % + seminar paper 40 % + seminar paper presentation 20 %.		

6. THEORY PRINCIPLES OF THE GRAVITY CONCENTRATION Content

Study program: Mining Engineering
Level of study: Doctoral Academic Studies
Course: THEORY PRINCIPLES OF THE GRAVITY CONCENTRATION
Lecturer: Dr Jovica M. Sokolović, associate professor
Course status: Elective course
ECTS: 15
Prerequisites: Acquired knowledge in underground and master academic studies
Course goals: Introduction to theoretical and practical principles of selected chapters of gravity methods of concentration.
Learning outcomes: Training students for independent scientific and research work in the field of gravity concentration of primary or secondary raw materials, or continuation of training in this field.
Course description: ***Theory*:** Theory of motion of the body in fluids, water, air, heavy liquids and suspensions. Free and subtracted (disturbed) motion of particles. Stability and viscosity of fluids. Criteria of gravity concentration and separability of raw materials in concentration processes in individual fluid (media). Choice of medium for gravity concentration. Control of technological indicators of the separation sharpness in processes of gravity concentration. Mathematical prediction of industrial results of the gravity concentration based on laboratory tests. Modeling the functional dependencies of technological indicators on the characteristics of the raw material and the possibilities of the device for gravity concentration. Optimization of technological processes of gravity concentration.
Literature **Recommended:** 1. R. Ignjatović, Theory of gravity concentration (in Serbian), Bor, 1980. 2. R. Ignjatović, Physical methods of concentration (in Serbian), Bor, 1983. 3. N. Ćalić, Theoretical basis for the preparation of mineral raw materials (in Serbian), Belgrade, 1990. 4. R. Ignjatović, M. Ignjatović, R. Stanojlović, Theoretical principles of the operation of static devices with electromagnetic valve in the gravity concentration of mineral raw materials (in Serbian), Bor, 1992. 5. M. Ignjatović, R. Ignjatović, M. Trumić, Principles of separator work with suspensions (in Serbian), Belgrade, 1999. 6. B.A. Wills, Mineral Processing Technology. Elsevier, Oxford, 2006. 7. J. Drzymala, Mineral Processing. Foundations of theory and practice of minerallurgy, Wroclaw, 2007.

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

Methods of teaching: Lectures with interactive discussions, consultations, experimental work, study research work, independent work.
Grading system (max. number of points 100)
Exam 40 %, independent work 40 % and active participation during classes and study research work 20 %.

7. THEORY OF ELEMENTARY PHYSICAL - CHEMICAL PROCESSES IN FLOTATION

Content

Study program: Mining Engineering		
Level of study: Doctoral Academic Studies		
Course: THEORY OF ELEMENTARY PHYSICAL - CHEMICAL PROCESSES IN FLOTATION		
Lecturers: Dr Maja Trumić, assistant professor; Dr Zoran Štirbanović, assistant professor;		
Course status: Elective course		
ECTS: 15		
Prerequisites: Required knowledge in the fields of physical chemistry and theoretical principles of flotation		
Course goals: Introduction to interface phenomena (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 M.E.Karaman, Applied Colloid and Surface Chemistry, John Wiley&Sons Inc., 2004. ISBN 0 470 86882 1. 7. M.W.Roberts and J.M.Thomas, Chemical Physic of Solids and their Surfaces, Billing&Sons Ltd., 1980. ISBN 0-85 186-740-5. 8. P.Somasundaran and D.Wang, Solution Chemistry: Minerals and Reagents. Elsevier, 2006. ISBN 13-978-0-444 52059-3. 9. Other literature of the latest publications in top-level journals in this field		
Number of classes per week:	Lectures: 6	Study research work: 4
Methods of teaching: Oral presentation and discussion, written work (seminar paper).		
Grading system (max. number of points 100)		
30 % oral exam + 50 % seminar paper + 20 % seminar paper defense.		

8. SPECIFIC TECHNOLOGIES OF SURFACE AND UNDERWATER MINING Content

Study program: Mining Engineering		
Level of study: Doctoral Academic Studies		
Course: SPECIFIC TECHNOLOGIES OF SURFACE AND UNDERWATER MINING		
Lecturer: Dr Miodrag Žikić, associate professor		
Course status: Elective course		
ECTS: 15		
Prerequisites: Completed courses of undergraduate and graduate studies.		
Course goals: Introduction to specific technologies of surface and underwater mining		
Learning outcomes: Individual competences for method selection, application and design.		
Course description: ***Theory***: Introductory remarks. Conditioning specific technology application – ore deposit properties. Review of specific technologies. Technology selection criteria. Technical and economic assessment of selected technology. Remediation of degraded areas. ***Study and research***: Assignment – Design of a specific technology for given conditions.		
Literature: **Recommended:** 1 V. Popović, Tehnologija površinske eksploatacije, RGF, Beograd, 1992. 2. V. Pavlović, Sistemi povšinske eksploatacije, RGF, Beograd, 1998. 3. A. Lazić, Projektovanje površinskih kopova, RGF, Beograd, 1998. **Supplementary:** 1 N. Popović, Naučne osnove projektovanja površinskih kopova, NIRO Zajednica, Oslobođenje, Sarajevo, 1984. 2. V. Pavlović, Rekultivacija povšinskih kopova i odlagališta, RGF, Beograd, 2000.		
Number of classes per week:	Lectures: 6	Study research work: 4
Methods of Teaching: Oral lectures, laboratory and calculus practicals, discussion.		
Grading system (maximum number of points 100)		
Exam 40 %, independent work 40 % and active participation during classes and study research work 20 %.		

9. THEORY OF ELECTROMAGNETIC PROCESS OF CONCENTRATION Content

Study program: Mining Engineering		
Level of study: Doctoral Academic Studies		
Course: THEORY OF ELECTROMAGNETIC PROCESS OF CONCENTRATION		
Lecturer: Dr Jovica M. Sokolović, associate professor		
Course status: Elective course		
ECTS: 15		
Prerequisites: Knowledge acquired in the undergraduate and master academic studies		
Course goals: Introduction to theoretical and practical principles of selected chapters of electromagnetic process of concentration		
Learning outcomes: Training students for independent scientific research work, or continuation of training in the field of electromagnetic concentration of primary or secondary raw materials.		
Course description: ***Theory*:** Theoretical principles of magnetic concentration. Phenomenology of magnetism. Magnetic properties of minerals. Magnetic properties of materials. Hysteresis of the magnetization and factor of demagnetization. Sources of magnetic field. Development of permanent magnets and superconductive materials. Theoretical analysis of magnetic concentration. Equations of motion of particles in the magnetic field of the separator. Calculate the critical particle diameter. Modern trends in the development of magnetic concentration devices. Magnetic separators with swirling currents. Analysis of force acting on a particle in the working area of a magnetic separator with turbulent currents. Magnetic flocculation. Force and conditions for elimination of flocculation. Control and regulation of individual parameters in processes of magnetic concentration. Theoretical basis of electrical phenomena and principles of electrical concentration methods. Electrical conductivity of conductors and semiconductors, Dielectric permeability. Electrical field: homogeneous, non-homogeneous, field of emptying the corona. Field strengths, electrical attraction forces: electrostatic and ponderomotive force. Behavior of conductors and non-conductors in the electric field. Grain electrisation: the possibility of increasing the difference in electro-physical properties of mineral and secondary raw materials. A separation zone of electric separator: forces acting on kernels of different electrical conductivity in separator zone. Modern trends in the development of devices for electrical concentrations. Control and regulation of individual parameters of the concentration process.		
Literature **Recommended:** 1. R. Ignjatović, Physical methods of concentration (in Serbian), Bor, 1983. 2. N. Ćalić, Theoretical basis for the preparation of mineral raw materials (in Serbian), Belgrade, 1990. 3. M. Ignjatović, Magnetic separation, new trends in the preparation of mineral raw material (in Serbian), Belgrade, 1997. 4. J. Svoboda, Magnetic techniques for the treatment of materials, Springer, 2004. 5. J. Drzymala, Mineral Processing. Foundations of theory and practice of minerallurgy, Wroclaw, 2007. 6. O. Ralston, Electrostatic separation of mixed granular solids, Elsevier, Amsterdam, 1961.		
Number of classes per week	Lectures: 6	Study research work: 4
Methods of teaching: Lectures with interactive discussions, consultations, experimental work, study research work, independent work.		
Grading system (max. number of points 100)		
Exam 40 %, independent work 40 % and active participation during classes and study research work 20 %.		

10. THEORETICAL PRINCIPLES OF CONCENTRATION CHEMICAL METHODS Content

Study program: Mining Engineering		
Level of study: Doctoral Academic Studies		
Course: THEORETICAL PRINCIPLES OF CONCENTRATION CHEMICAL METHODS		
Lecturer: Dr Grozdanka Bogdanović, full professor		
Course status: Elective course		
ECTS: 15		
Prerequisites: Required knowledge in leaching and solutions processing		
Course goals: Introduction to the 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. 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, Hidrometalurgija, ŠRIF, Bor, 1980. 3. V.Stanković, Fenomeni prenosa i operacije u metalurgiji. Knjiga 2. Prenos toplote i mase, Tehnički fakultet u Boru, Univerziteta u Beogradu, 1998 (Selected chapters). 4. G.D.Bogdanović, M.M.Antonijević, Ponašanje i oksidacija halkopirita u vodenoj sredini, Univerzitet u Beogradu, Tehnički fakultet, Bor, 2011. 5. Using literature from available databases (SCOPUS, SCIENCEDIRECT, WEB of SCIENCE, PROQUEST, COMPENDEX, ect.).		
Number of classes per week	Lectures: 6	Study research work: 4
Methods of teaching: Oral presentation and discussion, written work (seminar paper).		
Grading system (max. number of points 100)		
30 % oral exam + 50 % seminar paper + 20 % seminar paper defense		

11. NONTRADITIONAL UNDERGROUND MINING TECHNOLOGIES Content

Study program: Mining Engineering		
Level of study: Doctoral Academic Studies		
Course: NONTRADITIONAL UNDERGROUND MINING TECHNOLOGIES		
Наставник: Dr Vitomir Milić, full professor		
Course status: Elective course		
ECTS: 15		
Prerequisites: 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.		
Course description: ***Theory***: 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 **Supplementary:** 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,		
Number of classes per weak:	Lectures: 6	Study research work: 4
Methods of Teaching: Oral lectures, laboratory and calculus practicals, discussion.		
Grading system (maximum number of points 100)		
Exam 40 %, independent work 40 % and active participation during classes and study research work 20 %.		

12. INTELLIGENT SYSTEMS FOR SUPERVISION

Content

Study program: Mining Engineering				
Level of study: Doctoral Academic Studies				
Course: INTELLIGENT SYSTEMS FOR SUPERVISION				
Lecturer: Dr Zoran Stević, full professor; Dr Dejan Tanikić, associate professor; Dr Vladimir Despotović, assistant professor				
Course status: Elective course				
ECTS: 15				
Prerequisites:				
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 supervision and the decision making processes.				
Course description: ***Theoretical teaching****:* 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 data bases. 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. ***Practical teaching****:* Practicals. Other forms of teaching. Practical application of the obtained knowledge in accordance with the listed thematic topics.				
Literature: 1. W. Pedrycz, Computational Intelligence: An Introduction, CRC Press, 1998. 2. L. C. Jain, N. M. Martin, Fusion of Neural Networks, Fuzzy Systems and Genetic Algorithms: Industrial Applications, CRC Press, 1998. 3. Neural Networks, Algorithms, Applications, and Programming Techniques, Addison-Wesley Publishing Company, Inc., 1991. 4. D. Tanikić, Veštačke neuronske mreže, fazi logika i genetski algoritmi, Univerzitet u Beogradu, Tehnički fakultet u Boru, Bor, 2016. 5. Z. Miljković, Sistemi veštačkih neuronskih mreža u proizvodnim tehnologijama, Mašinski fakultet Beograd, 2004. 6. P. Subašić, Fazi logika i neuronske mreže, Tehnička knjiga, Beograd, 1997.				
Number of classes per week:				Other classes:
Lectures: 2	Practicals: 1	Other forms of teaching: 1	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			

13. FUNDAMENTALS OF SOIL REMEDIATION

Content

Study program: Mining Engineering		
Level of study: Doctoral Academic Studies		
Course: FUNDAMENTALS OF SOIL REMEDIATION		
Lecturers: Dr Milan M. Antonijević, full proffesor, Dr Grozdanka Bogdanović, associate professor; Dr Ana Simonović, assistant professor		
Course status: Elective course		
ECTS: 15		
Prerequisites: Necessary knowledge in the field of pollution and soil protection.		
Course goals: Introduction to the chemistry of solutions, interaction of pollutants with soil components and methods of remediation of polluted soil. The program will allow students to independently examine soil and propose appropriate methods for the elimination of pollutants.		
Learning outcomes: Students will be trained for independent scientific and professional work in this field.		
Course description Chemistry of soil. Soil analysis. Solvability of soil components. Carbonate balance. Reactions of ion exchange in the soil. Adsorption processes. Acid-base equilibrium. Redox processes in the soil. Inorganic and organic pollutants. Interaction of polutants with soil components. Remediation Technologies. Bioremediation. Chemical oxidation. Thermal desorption. Electrokinetic remediation of soil. Soil washing. Extraction methods of soil remediation. Soil calcification and reduction of salinity. Fitoremediation. Separation of heavy metals. Other remediation techniques.		
Literature: ***Recommended****:* 1. R.G. Buran and R.J. Zasoski, Soil and water shemistry, U.C. Davis, 2002. 2. R. Burt, Soil Survey Laboratory Methods Manual, NRCS, USA 2004. 3. M. Rosa, S. 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. Using literature from available databases (SCOPUS, SCIENCEDIRECT, WEB of SCIENCE, PROQUEST, COMPENDEX, etc).		
Number of active classes:	Lectures: 6	Study research work: 4
Methods of teaching: Oral presentation and discussion, written work (term paper).		
Grading system (max. number of points 100)		
Oral exam 30% + preparation of term paper 50% + term paper defense 20%		

14. DOCTORAL DISSERTATION – DEFINING THEME

Content

Study program: Mining Engineering		
Level of study: Doctoral Academic Studies		
Course: DOCTORAL DISSERTATION – DEFINING THEME		
Lecturer: All professors from the study program eligible to be mentors		
Course status: Obligatory course		
ECTS: 15		
Prerequisites: All exams at the PhD level successfully passed		
Course goals: 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 courses.		
Learning outcomes: The student will be trained to become capable of carrying on analysis and synthesis of the doctoral level course level, on his/her own, as well as to become capable of applying gained knowledge in structuring a research problem and defining 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.		
Course description: 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 at 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 the above tasks will result in a written report – seminar paper that will be defended in front of the commission consisting of three members, 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 publications from the „Kobson“ list.		
Number of classes per week	Lectures: 0	Study research work: 20
Methods of teaching Mentor assigns 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 student's work on the final elaborate, the mentor can be involved with the adequate suggestions and instructions that will result in the high quality of explanation of the scientific contribution and adequacy of the selected theme of the dissertation. During his/her work on the elaborate, the student shall conduct all the necessary experiments, measurements, analysis and other research work, with the aim to define and explain the research problem, as well as possible. After defending the elaborate, the mentor will start the procedure for the official acceptance of the doctoral dissertation theme.		
Grading system (max. number of points 100)		

15. DOCTORAL DISSERTATION – RESEARCH WORK 1

Content

Study program: Mining Engineering		
Level of study: Doctoral Academic Studies		
Course: DOCTORAL DISSERTATION – RESEARCH WORK 1		
Lecturer: All professors from the study program eligible to be mentors		
Course status: Obligatory course		
ECTS: 30		
Prerequisites: All exams at the PhD level successfully passed		
Course goals: 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 course of the doctoral dissertation. Through the defined theme of the doctoral dissertation, student studies 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 acquiring necessary experience for the independent structuring of the research problem and finding the solutions for solving it.		
Learning outcomes: The student will be trained to become capable of practically applying the knowledge generated through the courses of this study program and using it in solving the defined practical problem. Through the independent application of the literature resources from the available data bases, the student will expand his/her knowledge and will become capable of using the contemporary methods and tools in solving the predefined research problems.		
Course description: The course contents is to be prepared for each student individually, in line with the requirements of his/her future work. The student will review scientific literature and conduct necessary research work, which is connected with the course of the doctoral thesis theme (laboratory research, field work research, etc.). The dominant resources to be used by the student, through his/her individual research work are journals from the SCI list.		
Literature Available scientific journal publications from the „Kobson" list.		
Number of classes per week	Lectures: 0	Study research work: 20
Methods of teaching The mentor assigns the research task, with the proposition of main research directions, that resulted from the defined and defended research elaborate, during the definition of the doctoral dissertation theme course. During student's work on the doctoral thesis, the mentor can be involved with adequate suggestions and instructions that will result in high quality of the final content of the doctoral dissertation.		
Grading system (max. number of points 100)		

16. DOCTORAL DISSERTATION – RESEARCH WORK 2

Content

Study program: Mining Engineering		
Level of study: Doctoral Academic Studies		
Course: DOCTORAL DISSERTATION – RESEARCH WORK 2		
Lecturer: All professors from the study program eligible to be mentors		
Course status: Obligatory course		
ECTS: 30		
Prerequisites: All exams at the PhD level successfully passed		
Course goals: 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 course of the doctoral dissertation. Through defined theme of the doctoral dissertation, student studies the problem, its structure and complexity, conducts analysis and synthesis and defines the potential directions for its solution. The goal of student's activities, at this study level is in acquiring necessary experience for the independent structuring of the research problem and finding the solutions for solving it.		
Learning outcomes: The student will be trained to become capable of practically applying the knowledge generated through the courses 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 of using the contemporary methods and tools in solving the predefined research problems.		
Course description: The course content is to be prepared for each student individually, in line with the requirements of his/her future work. The student will review scientific literature and conduct necessary research work, which is connected with the course of the doctoral thesis theme (laboratory research, field work research, etc.). The dominant resources to be used by the student, through his/her individual research work are journals from the SCI list.		
Literature Available scientific journal publications from the „Kobson" list.		
Number of classes per week	Lectures: 0	Study research work: 20
Methods of teaching The mentor assigns the research task, with the 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 in high quality of the final content of the doctoral dissertation.		
Grading system (max. number of points 100)		

17. DOCTORAL DISSERTATION – RESEARCH WORK 3 Content

Study program: Mining Engineering		
Level of study: Doctoral Academic Studies		
Course: DOCTORAL DISSERTATION – RESEARCH WORK 3		
Lecturer: All professors from the study program eligible to be mentors		
Course status: Obligatory course		
ECTS: 10		
Prerequisites: All exams at the PhD level successfully passed		
Course goals: 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 course 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.		
Learning outcomes: The student will be trained to become capable of practically applying the knowledge generated through the courses 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 of using the contemporary methods and tools in solving the predefined research problems.		
Course description: The course content is to be prepared for each student individually, in line with the requirements of his/her future work. The student will review scientific literature and conduct the necessary research work connected with the course of the doctoral thesis theme (laboratory research, field work research, etc.). The dominant resources to be used by the student through his/her individual research work are journals from the SCI list.		
Literature Available scientific journal publications from the „Kobson“ list.		
Number of classes per week	Number of classes per week	Number of classes per week
Methods of teaching The mentor assigns the research task, with the proposition of main research directions that resulted from the defined and defended research elaborate, during the definition of the doctoral dissertation theme course. During student's work on the doctoral thesis, the mentor can be involved with adequate suggestions and instructions that will result in high quality of the final content of the doctoral dissertation.		
Grading system (max. number of points 100)		

18. DOCTORAL DISSERTATION – REALIZATION AND DEFENSE OF THESIS Content

Study program: Mining Engineering		
Level of study: Doctoral Academic Studies		
Course: DOCTORAL DISSERTATION – REALIZATION AND DEFENSE OF THESIS		
Lecturer: All professors from the study program eligible to be mentors		
Course status: Obligatory course		
ECTS: 20		
Prerequisites: All exams at the PhD level successfully passed		
Course goals: Successful doctoral dissertation defense.		
Learning outcomes: After successful and independent work on the doctoral dissertation and its preparation in the written form, from the scientific field of technical sciences which was selected by the student after the enrollment, the student is obligated to: - submit the final text of the written doctoral dissertation, - defend the doctoral dissertation in front of the commission, if previously succeeded in publishing at least one manuscript in a journal from the SCI list.		
Course description: During writing the doctoral dissertation, the student should present the text in the form that should include following chapters: title, introduction, literature review, research hypothesis and the aim of the research, material and methods, results, discussion, conclusions, list of references.		
Literature All available domestic and foreign literature referring to the scientific field from which the PhD 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 using predefined methods and results processing, followed by writing the dissertation, accompanied by continuous consultations with the mentor and the commission members.		
Grading system (max. number of points 100)		
Research, writing doctoral dissertation	50	
Presentation and doctoral dissertation defense	50	