University of Belgrade Technical faculty in Bor	
Accreditation of the study program	
METALLURGICAL ENGINEERING	MASTER ACADEMIC STUDIES

METALLURGICAL ENGINEERING

MASTER ACADEMIC STUDIES

BOOK OF COURSES

List of courses:

2013.

Study program: Metallurgical Engineering

Level of study: Master Academic Studies

Course: PHYSICAL METALLURGY 3

Lecturer: Dr. Desimir Markovic, full professor

Course status: Obligatory course for Metallurgical Engineering study program

ECTS: 8

Prerequisites: Required knowledge on Physical Metallurgy 1 and Physical Metallurgy 2

Course goals:
Acquiring knowledge in the field of solid state physics and metal physics

Learning outcome:
Acquiring knowledge and successfully following the classes in other courses from the field

Course description:
Theory teaching
Crystal structure. Elements of crystallography. Crystal diffraction and reciprocal lattice. Chemical bonds in crystals. Elastic constants. Elastic properties of solids. Relaxation in solids. Internal friction. Phonons and vibrations in lattice. Electron theory of metals. The theory of free electrons. Fermi energy and Fermi level. Energy zones. Electrical properties of metals. Electron theory of electrical conductivity. Semiconductor crystals. Superconductivity. Metal thermal properties. Ferroelectric crystals. Diamagnetism and paramagnetism. Ferromagnetism and antiferromagnetism. Magnetic resonance. Point defects in crystals. Vacancies. Dislocation. Dislocations and slipping. Geometry and dislocation movement. Elastic properties of dislocations. Multiplication and mobility of dislocations. Dislocation reactions. Deformation strengthening of crystals, polycrystalline aggregates and solid solutions. Precipitation and dispersion strengthening.
Practical classes: Practicals, Other forms of teaching, Study research work
Theoretical classes are followed parallel by laboratory practicals in the field of structural analysis, deformation strengthening, and precipitation and dispersion strengthening.

Literature
Recommended:
1. Čarls Kitel, Uvod u fiziku čvrstog stanja (Introduction to Solid State Physics), Savremena administracija, Beograd, 1970. (*in Serbian*)
2. D. Hull, D. J. Bacon, Introduction to Dislocations (fifth edition), Elsevier Butterworth-Heinemann, 2011.
3. W. D. Callister Jr, D. G. Rethwisch, Materials Science and Engineering – An Introduction (eight edition), John Wiley & Sons, 2010.
4. Boško Perović, Fizička metalurgija (Physical metallurgy), Metalurško-tehnološki fakultet, Podgorica, 1997. (*in Serbian*)
5. Đorđe Drobnjak, Fizička metalurgija. Fizika čvrstoće i plastičnosti 1, Tehnološko-metalurški fakultet, Beograd, 1990. (*in Serbian*)
6. R. Abbaschian, L. Abbaschian, R.E. Read-Hill, Physical Metallurgy Principles (fourth edition), Cengage Learning, 2009.
Supplementary:
1. Manijeh Razeghi, Fundamentals of Solid State Engineering, Kluwer Academic Publishers, New York, 2002.
2. R. E. Hummel, Understanding Materials Science (Second Edition), Springer-Verlag, New York, 2004.

Number of classes per week				Other classes:
Lectures: 3	Practicals: 1	Other forms of teaching: 2	Study research work:	

Methods of teaching
Classical lectures, practicals

Grading system(max. number of points 100)

Pre-examination requirements	**Number of points**	**Final examination**	**Number of points**
Attendance and active participation	5	Written exam	
Practicals	15	Oral exam	50
Preliminary examination			
Seminar paper	30		

Study program: Metallurgical Engineering

Level of study: Master Academic Studies

Course: MATERIALS CHARACTERIZATION

Lecturers: Dr. Mirjana Rajčić Vujasinović, full professor, Dr. Nada Štrbac, full professor and Dr. Ljubiša Balanović, assistant professor

Course status: Obligatory course

ECTS: 8

Prerequisites: Required knowledge on physical chemistry, physical metallurgy and metal testing

Course goals:
The aim of this course is to introduce students to methods of characterization of solid materials, primarily metals and fluids, which is of fundamental importance for the field of metallurgical engineering and engineering of metal materials.

Learning outcome:
Students gain knowledge on the most important methods of characterization, theoretically prepared for the adoption of modern methods and being trained in practicals for their use.

Course description:
Theoretical lectures
Characterization of solid materials.
Sampling and sampling errors. Chemical and rational analysis. Destructive and non-destructive methods. Microscopic analysis. Study of the structure by using X - ray diffraction. Physical methods for determination of properties. Mechanical materials testing by static and mechanical action of force. Thermochemical characterization. Characterization of powders and sintered materials. Electrochemical methods of characterization.
Characterization of liquids. Vapor tension. Viscosity. Ideal and non-ideal liquid mixtures and solutions. Activities of the solution components.
Practical classes: Practicals; other forms of lectures; study research work.
Laboratory practicals in the field of application of the listed methods of characterization.

Literature
Recommended:
1. B. D. Fahlman, Materials Chemistry, Springer, Dordrecht, 2008.
2. J. Mišović, Instrumentalne metode hemijske analize, TMF, Beograd, 1978. (in Serbian)
3. П.П. Арсентев и други, Физико-химические методи иследованија метллургических процессов, Металлургија, Москва, 1988. (in Russian)
4. J.P. Sibilia, A Guide to Materials Characterization, VCH Publishers, 1988.
5. V. K. Pecharsky, P. Y. Zavalij, Fundamentals of powder diffraction and structural characterization of materials, Springer science and Business media, 2003.
6. D. B. Murphy, Fundamentals of Light Microscopy and Electronic Imaging, Willey - Liss, 2001.
Supplementary:
1. Yu. Lyalikov et al., Problems in physicochemical methods of analysis, Mir Publishers, Moscow, 1974.
2. S. Đorđević, V. Dražić, Fizička hemija, četvrto izdanje, TMF, Beograd, 2000. (in Serbian)
3. M. Rajčić Vujasinović, Z. Stanković, Fizička hemija, Praktikum za vežbe, TF Bor, 2001. (in Serbian)

Number of classes per week				**Other classes:**
Lectures: 3	**Practicals: 1**	**Other forms of teaching: 2**	**Study research work:**	

Methods of teaching
Lectures with interactive discussions, laboratory practicals, seminar paper, consultations.

Grading system(max. number of points 100)

Pre-examination requirements	**Number of points**	**Final examination**	**Number of points**
Attendance and active participation	**10**	**Written exam**	
Practicals		**Oral exam**	**50**
Preliminary examination			
Independent work	**40**		

Study program: Metallurgical Engineering and Technological Engineering

Level of study: Master Academic Studies

Course: THERMODYNAMICS OF MATERIALS

Lecturers: Dr. Ljubiša Balanović, assistant professor and Dr. Aleksandra Mitovski, assistant professor

Course status: Elective course for study programs Metallurgical Engineering and Technological Engineering

ECTS: 6

Prerequisites: Knowledge on Thermodynamics and Physical chemistry is required

Course goals:

Acquisition of necessary theoretical and experimental knowledge in the field of thermodynamics of materials, as well as consideration of connections between thermodynamic and other physical and chemical characteristics of materials.

Learning outcome:

Training for independent work on calculations in the field of thermodynamics of materials and in the usage of basic apparatus for thermal analysis and calorimetry, as well as mastering the application of some of the modern thermodynamic software.

Course description:

Lectures

Thermodynamics of solutions. Models of solutions. Analytical thermodynamic research. Calculations based on the known phase diagram. Thermodynamic properties prediction of multicomponent metal systems. Thermodynamic modeling. Multicomponent solutions. The relationship between thermodynamic and other physical and chemical characteristics of the alloys - viscosity, surface tension, density, etc. Solid state thermodynamics. Diffusion. Surfaces and phases. Experimental methods in the thermodynamics of materials.

Practical classes: Practicals, Other forms of teaching, Study research work

Calculation practicals. Laboratory thermodynamic investigations: calorimetric methods, methods based on EMS measurement, gas phase equilibrium. Laboratory work on basic thermal analysis apparatus. Application of thermodynamic computer software (HSC, Thermocalc, FACT, etc.).

Literature

Recommended:

1. Д. Живковић, Термодинамика материјала, Ауторизована предавања, Технички факултет Бор, 2007. (*in Serbian*)
2. S. Stolen, T. Grande, N. Allan, Chemical Thermodynamics of Materials, John Willey&Sons, New York, 2004.
3. C.H.P. Lupis, Chemical Thermodynamics of Materials, Metallurgia, Moscow, 1989. (*in Russian*)
4. R.A.Swallin, Thermodynamics of Solids, John Willey&Sons, New York, 1962.
5. O. Kubaschewski, C.B. Alcock, Metallurgical Thermochemistry, Pergamon Press, Oxford, 1983.

Supplementary:

1. V. Gontarev, Termodinamika materialov, Univerza u Ljubljani, NTF, Ljubljana, 2000.
2. Thermal analysis of materials, R.F.Speyer, Marcell Dekker, New York, 1994.
3. Ж. Живковић, Б. Добовишек, ДТА – теорија и примена, ТФ, Бор, 1984. (*in Serbian*)
4. N. Saunders, A.P. Miodownik, CALPHAD, calculation of phase diagrams, a comprehensive guide, Pergamon Materials Series - Elsevier, Oxford, 1998.
5. P. Gabbott, Principles and Applications of Thermal Analysis, Blackwell Publishing, 2007.
6. G. Kostorz, Phase Transformations in Materials, Wiley-VCH Verlag GmbH, 2001.

Number of classes per week				Other classes:
Lectures: 2	Practicals: 1	Other forms of teaching: 1	Study research work:	

Methods of teaching: Lectures, calculations and laboratory practicals organized on an interactive basis, with the elaboration of practical examples through a group, individual and combined method of work.

Grading system(max. number of points 100)

Pre-examination requirements	**Number of points**	**Final examination**	**Number of points**
Attendance and active participation	5	Written exam	20
Practicals	20	Oral exam	20
Preliminary examination	5		
Independent work	30		

Study program: Metallurgical Engineering

Level of study: Master Academic Studies

Course: SINTERING THEORY

Lecturer: Dr. Ivana Markovic, assistant professor

Course status: Elective course

ECTS: 6

Prerequisites: Required knowledge on Physical Metallurgy and Powder Metallurgy

Course goals:
The investigation of transport materials mechanisms in the sintering process of metallic materials and composites.

Learning outcome:
Acquisition of theoretical knowledge on the sintering process in solid state and liquid state, to enable students to have the necessary basis for the course in the same field at the doctoral study.

Course description:
Theoretical classes:
Solid state sintering. Mechanisms of mass transport: viscous flow, evaporation-condensation, surface diffusion, volume diffusion, grain boundary diffusion, plastic flow. Sintering stages: adhesion, rearrangement, initial stage of neck creation, middle stage, final stage, sintering rate calculation, sintering diagrams. Microstructure and processes in solid state sintering (packing of particles, pore structure, grain structure, microstructure formation, heating rate).
Solid-phase sintering of powder mixtures (physical and chemical interaction), behavior of powder mixtures during sintering, particle packing, shrinking, density increase, homogenization kinetics. Activated sintering. Control of the microstructure. *Liquid phase sintering.* Key thermodynamic and kinetic factors, wettability, capillary, viscous flow in the system solid-liquid, phase diagrams. Stage of heating and melting: formation of liquid phase, particle rearrangement. Stage dissolution - precipitation: densification, contact formation, neck growth, coalescence, pores filling. Formation of microstructure: grain growth and other structural changes. Characterization of the microstructure. Sintering under the pressure: plastic flow, viscous flow, creep. New sintering techniques: supersolidus liquid-phase sintering, infiltration, activated liquid-phase sintering.
Practical classes: Practicals, Other forms of teaching, Study research work
Lectures, practicals are organized on an interactive principle. In addition to classical lectures and presentations discussions and active participation of students in all aspects of teaching are included.

Literature
Recommended:
1. Randal M. German, Sintering Theory and Practice, The Pennsylvania State University, 1996.
2. Mirjana Mitkov, Dušan Božić, Zoran Vujović, Metalurgija praha (Powder Metallurgy), Beograd, 1998. (*in Serbian*)
3. Suk-Joong L. Kang, Sintering, Elsevier Butterworth- Heinemann, 2005.
4. Svetlana Nestorović, Sintermetalurgija, Praktikum, Bor, 2001. (*in Serbian*)
Supplementary:
1. С. С. Кипарисов, Г.А. Либенсон, Порошковаја металургија, Москва, 1972. (*in Russian*)
2. В.А. Ивенсен, Кинетика уплотнениja металическиј порошков при спекании, Металлургија, Москва, 1971. (*in Russian*)
3. Standard Test Methods for Metal Powders and Powder Metallurgy Products, Metal Powder Industries Federation, Princeton, New Jersey, U.S.A. 1999.

Number of classes per week				Other classes:
Lectures: 2	Practicals: 1	Other forms of teaching: 1	Study research work:	

Methods of teaching
Lectures and practicals are organized on an interactive principle, which besides classical lectures and presentations include discussions and active participation of students in all aspects of teaching.

Grading system(max. number of points 100)

Pre-examination requirements	**Number of points**	**Final examination**	**Number of points**
Attendance and active participation	5	Written exam	
Practicals	15	Oral exam	30
Preliminary examination	2 x 25 = 50		
Independent work			

Study program: Metallurgical Engineering

Level of study: Master Academic Studies

Course: KINETICS OF PHASE TRANSFORMATIONS

Lecturer: Dr. Svetlana Lj. Ivanov, associate professor

Course status: Elective course

ECTS: 6

Prerequisites: Requires knowledge on Physical chemistry and Physical metallurgy

Course goals:

Goal of this course is to introduce students to fundamental aspects of kinetics of phase transformations that take place in the processes of deformation, heat treatment and joining the metallic materials.

Learning outcome:

Student are trained to control the conditions of phase transformation processes and with that acquire a certain structure, and with that the metallic materials with different properties.

Course description:

Theoretical classes:

Introduction (basis of kinetic theory, methods for determining the kinetic of reactions, equations for homogenous and heterogeneous reactions, Arrhenius equation). *Diffusion in metals and alloys.* Diffusion process by atoms moving in solid state. Interstitial and substitutional diffusion. Diffusion in alloys. Darkens' equation. Negative diffusion or "uphill" diffusion. Paths of increased diffusion. Diffusion along the dislocations, intermediate boundary surfaces, grain boundary and free surfaces. *Phase transformations liquid-solid.* Nucleation and kinetic processes on boundary surfaces liquid-solid. Crystal growth. Fast solidification. Crystallization of amorphous materials. *Phase transformations in solid state*. Diffusional and non-diffusional (shear) transformations. Nucleation in solid phase – homogenous and heterogeneous nucleation sites. Intermediate boundaries and nucleation site shape. Kinetics of phase transformations. Transformation rate. CCT and TTT diagrams. Johnson-Mehl-Avrami-Kolmogorov equation. The influence of defects on kinetics of phase transformations. Impact of cooling rates on morphology of the new phase. Diffusional dependent phase transformations: spinodal decomposition, precipitation from super saturated solid solution, coarsening of precipitates, eutectoid transformation and discontinuous precipitation, massive transformation. Non-diffusional phase transformation. Martensitic transformation. Characteristics and kinetics of martensite formation. Thermoelastic martensite and shape memory effect. Shear and diffusional transformation combination. Bainite transformation.

Practical classes: Theoretical studies are followed by laboratory practicals in the field of phase transformations while deforming, heat treating and joining the metallic materials.

Literature

Recommended:

1. J. Бурке, Кинетика фазних трансформација у металима - превод с енглеског М. Рогулић, Технолошко-металуршки факултет, Београд, 1980. (*in Serbian*)
2. B. Perović, Fizička metalurgija, Metalurško-tehnološki fakultet, Podgorica 1997. (*in Serbian*)
3. J.H. Brophy, R.M. Rose, J. Wulff, Структуре и особине материјала, Књига II: Термодинамика структуре-превод с енглеског Љиљана Радоњић, Технолошко-металуршки факултет, Београд, 1976. (*in Serbian*)

Supplementary:

1. D.A.Porter, K.E. Easterling, Phase Transformations in Metals and Alloys, Chapman and Hall, Second edition, 1992.
2. M.C. Flemings, Solidification Processing, McGraw-Hill Book Company, New York, 1974.
3. Чланци у међународним часописима из ове области. (*in Serbian*)

Number of classes per week				Other classes:
Lectures: 2	Practicals: 1	Other forms of teaching: 1	Study research work:	

Methods of teaching

Lectures and lab practicals.

Grading system(max. number of points 100)

Pre-examination requirements	**Number of points**	**Final examination**	**Number of points**
Attendance and active participation		Written exam	
Practicals	10	Oral exam	50
Preliminary examination	40		
Independent work			

Study program: Metallurgical Engineering

Level of study: Master Academic Studies

Course: TRANSPORT PHENOMENA 1

Lecturer: Dr. Vesna Grekulović, assistant professor

Course status: Elective course for study program Metallurgical Engineering and Obligatory course for the study program Technological Engineering

ECTS: 8

Prerequisites: Knowledge on mathematics and in mass, heat and momentum transfer is required

Course goals:
Introducing candidates to transport phenomena that occur in extractive metallurgy and metallurgical engineering, and an upgrading of the level of knowledge gained during undergraduate studies.

Learning outcome:
Students acquire advanced knowledge in the field of transport phenomena, with a special emphasis on training how to control and manage of these phenomena in chemical and metallurgical processes.

Course description:
Lectures:
Transport characteristics. Momentum transfer: transport mechanisms, boundary layer transport equations, some partial solutions of these equations; fluid flow regimes. Theory of similarity and dimensional analysis, similarity criteria. Heat transfer: transfer mechanisms; basic heat transfer equations. Heat transfer with the change of phases. Mass transfer: transport mechanisms, basic equations of molecular and convective mass transfer. Models of mass transfer. Interface mass transfer. Simultaneous transfer phenomena. Transfer analogies.
Practical classes:
Practicals, Other forms of teaching, Study research work. Calculation practicals following the lectures.

Literature
Recommended:
1. V. Stanković, Transport phenomena and operations in metallurgy 1, University of Belgrade, Technical Faculty in Bor ,1998. *(in Serbian)*
2. V. Stanković, Transport phenomena and operations in metallurgy 2, University of Belgrade, Technical Faculty in Bor ,1998. *(in Serbian)*
3. F. Zdanski, Mechanics of fluid, Faculty of Technology and Metallurgy, University of Belgrade; 1995. *(in Serbian)*
Optionally:
1. R.R.Bird, W.E.Stewart, N.Lightfoot, Transport phenomena, Willey&Sons, New York, 1960.
2. J.Szekely, N.J.Themelis, Rate Phenomena in Process Metallurgy, Willey Int., 1971.
3. G.H.Geiger, D.R. Poirier, Transport Phenomena in Metallurgy, Addison-Wesley Publ. Co., Reading Massachusetts, 1973.

Number of classes per week				Other classes:
Lectures: 3	Practicals: 2	Other forms of teaching: 1	Study research work:	

Methods of teaching
Lectures based on interactive principle and calculation practicals, with consultations.

Grading system(max. number of points 100)

Pre-examination requirements	**Number of points**	**Final examination**	**Number of points**
Attendance and active participation	20	Written exam	20
Practicals		Oral exam	20
Preliminary examination	2 x 20 = 40		
Independent work			

Study program: Metallurgical Engineering

Level of study: Master Academic Studies

Course: STRUCTURE AND PROPERTIES OF PRECIOUS METALS

Lecturer: Dr. Dragoslav Gusković, full professor

Course status: Elective course

ECTS: 8

Prerequisites: Required knowledge on physical chemistry, metal testing and physical metallurgy

Course goals:
The course should enable student to learn the structure and properties of precious metals, their interrelations, as well as interaction with other elements of the periodic table.

Learning outcome:
The student should learn the most important elements of the structure and properties of precious metals in order to obtain the necessary basis for combining them with the design and getting of new alloys with required properties and a wide range of applications.

Course description:
Theoretical study
Crystal structure. Electronic structure. Atomic properties. Thermal properties. Electrical properties. Optical properties. Mechanical properties. Chemical properties. Corrosion resistance. Physicochemical properties of gold, silver, platinum, palladium, radium, osmium, ruthenium and radium in liquid state. Binary phase diagrams of gold. Binary phase diagrams of silver. Binary phase diagrams of platinum metals. Ternary and multi-component phase diagrams of gold and silver. Alloy for dentistry. Application of precious metals and their alloys for electrical contacts, conductors, resistors, thermometers, tensometers, thermocouples, temperature-resistant structural materials, corrosion-resistant materials, catalysts, solders.
Practicals, Other forms of teaching, Study research work
Laboratory practicals follow lectures. Application of the phase diagram in the function of determining the properties of the alloys of the given composition.

Literature
Recommended:
1. П. Гертик, Племенити метали, П.Г., Београд, 1997. (*in Serbian*)
2. Е. М. Савитскиј, Благороднуе маталлу, Металлургија, Москва, 1984. (*in Russian*)
3. W. S. Rapson, T. Groenevald, Gold usage, Academic Press, London, 1978.
4. П. Гертик, Уметничка обрада метала, МПМ, Београд, 2004. (*in Serbian*)
5. G. Savitckij, Metallovedennye platinovyh splavov, Metallurgija, Moskva, 1975. (*in Russian*)
Supplementary:
1. V. M. Malysev, D. V. Rumjancev, Zoloto, Metallurgija, Moskva, 1979. (*in Russian*)
2. V. M. Malysev, D. V. Rumjancev, Serebro, Metallurgija, Moskva, 1979. (*in Russian*)
3. E. Moffat, The handbook of binary phase diagrams, General Electric, Schenectadiy, 1983.
4. А. Б. Бобулев, Механические и технологические својства металлов, Металлургија, Москва, 1987. (*in Russian*)
5. C. Corti, R. Holliday, Gold, Science and Applications, CRC Press and W.G. Council, London, 2010.

Number of classes per week				Other classes:
Lectures: 3	Practicals: 2	Other forms of teaching: 1	Study research work:	

Methods of teaching
Lectures and practicals are organized on an interactive principle, which besides classical lectures and presentations, include discussions and active participation of students

Grading system(max. number of points 100)

Pre-examination requirements	**Number of points**	**Final examination**	**Number of points**
Attendance and active participation	5	Written exam	
Practicals	40	Oral exam	55
Preliminary examination			
Independent work			

Study program: Metallurgical Engineering

Level of study: Master Academic Studies

Course: PHASE EQUILIBRIA

Lecturer: Dr. Dragan Manasijević, full professor

Course status: Elective course

ECTS: 6

Prerequisites: Required knowledge in the field of thermodynamics, theory of pyrometallurgical processes and physical metallurgy

Course goals:
The aim of the course is to familiarize students with the basic principles of phase equlibria analysis in multicomponent systems as the necessary basics for study and research in the field of metallurgical processes and new materials.

Learning outcome:
Student are trained for the use and application of phase diagrams in practice and in scientific research.

Course description:
Introduction to phase diagrams. Phase diagrams of unary systems. Binary phase diagrams. Connection between phase diagrams and thermodynamic properties. Eutectic, monotonic, peritectic reactions. Solid solutions. Miscibility gaps, Intermediate phases. Metastable phases. Ternary Systems. Thermodynamic models of solutions. Calculation of phase diagrams. CALPHAD method. Experimental methods of phase diagram determination. Calculation of phase diagrams of metallic systems using PANDAT program.

Literature
Recommended:
1. Dragan Manasijević, Fazne ravnoteže, Autorizovana predavanja, Tehnički fakultet u Boru, 2016. (*in Serbian)*
2. H. L. Lukas, S. G. Fries, B. Sundman, Computational Thermodynamics: CALPHAD method, Cambridge University Press, Cambridge, UK 2007.
Supplementary:
1. D. Minić, D. Manasijević, D. Živković, Ž. Živković, Fazne ravnoteže i termodinamika sistema Pb-Sb (In, Ga), TF Bor, 2007. (*in Serbian)*
2. N. Saunders, A.P. Miodownik, CALPHAD, Calculation of Phase Diagrams, A comprehensive guide, Pergamon Materials Series - Elsevier, Oxford, 1998.

Number of classes per week				Other classes:
Lectures: 2	Practicals: 1	Other forms of teaching: 1	Study research work:	

Methods of teaching
Lectures, laboratory and calculation practicals. Training for the use and application of PANDAT software package.

Grading system(max. number of points 100)

Pre-examination requirements	**Number of points**	**Final examination**	**Number of points**
Attendance and active participation	10	Written exam	
Practicals		Oral exam	60
Preliminary examination			
Seminar paper	30		

Study program: Metallurgical Engineering

Level of study: Master Academic Studies

Course: CONTI PROCEDURES FOR OBTAINING WIRE AND PROFILES

Lecturer: Dr. Dragoslav Gusković, full professor

Course status: Elective course

ECTS: 8

Prerequisites: Required knowledge on physical metallurgy and metal processing in plastic state

Course goals:
The course should enable the student to acquire knowledge and understand the basic principles of various procedures for the production of wire and profiles, with the greatest attention being paid to the combination of continuous casting and hot rolling with the same heat.

Learning outcome:
The student should learn the processes of continuous casting and rolling and to master the concrete production technologies of wire and small cross section profiles in order to be trained for efficient independent and team work in this field.

Course description:
Theoretical study
Division of manufacturing technologies. Semi-continuous and continuous casting. Types of crystallizers. Traditional procedures for obtaining wire and profiles. Contirod procedure, casting and hot rolling. Casting on a rotating wheel and hot rolling. Deep Forming procedure, immersion design technique and hot rolling. Properties of hot rolled wires. Upcast and Upward procedure. Properties of cast wires. Comparison of procedures and comparison of properties of obtained products. Continuous casting processes with extremely rapid cooling of the melt. Continuous pressing procedures.
Practicals, Other forms of teaching, Study research work
Calculation and laboratory practices follow lectures. Determination of the rate of recrystallization of the melt and the TMR of metal processing.

Literature
Recommended:
1. Д. Гусковић, Б. Станојевић, С. Стевић, Савремени поступци добијања бакарних жица, ТФ, Бор, 1997. (*in Serbian*)
2. М. Пешић, Б. Мишковић, В. Миленковић, Прерада метала у пластичном стању, ТМФ, Београд, 1989. (*in Serbian*)
3. W. Schwarrzmaier, Непреривнаја разливка, превод са немачког, Москва, Металлургија, 1962.
4. W. F. Hosford, R. M. Caddell, Metalforming: Mecechanics and Metallurgy, Prentice Hall, 3 ed., London, 2007.
5. Д. Гусковић, Добијање аморфних металних материјала из растопа брзим хлађењем, ТФ Бор, 2010. (*in Serbian*)
Supplementary:
1. М. Арсеновић, А. Костов, Ливење профила малих попречних пресека, Наука, Београд, 2001. (*in Serbian*)
2. С. Стојадиновић, Ш. Бешић, Е. Десница, Основи производних технологија, ТФ, Зрењанин, 2006. (*in Serbian*)
3. G. K. Bhat, Special Melting and Processing, Noyes Publications, 1989.
4. A. Sinha, Physical metallurgy Handbook, Mc Graw-Hill Education, 2002.
5. S. H. Herman, Ultrarapid Quenching of liquid Alloys, Academic press, N.Y., 1981.

Number of classes per week				Other classes:
Lectures: 3	Practicals: 1	Other forms of teaching: 2	Study research work:	

Methods of teaching
Theoretical and practical teaching in combination with interactive teaching will be conducted in all areas to varying degrees.

Grading system(max. number of points 100)

Pre-examination requirements	**Number of points**	**Final examination**	**Number of points**
Attendance and active participation	50	Written exam	25
Practicals	30	Oral exam	40
Preliminary examination			
Independent work			

Study program: Metallurgical Engineering

Level of study: Master Academic Studies

Course: METALLURGY OF NON-FERROUS ALLOYS

Lecturer: Dr. Srba Mladenović, associate professor

Course status: Elective course

ECTS: 8

Prerequisites:

Course goals:
Basic knowledge on non-ferrous alloys and their industrial production

Learning outcome:
Properties of non – ferrous alloys and technical information about furnaces for their production

Course description:
Introduction. Copper and copper alloys. Nickel and nickel alloys. Zinc and zinc alloys. Lead, ten and antimony alloys. High temperature melting metals and their alloys. Aluminum and aluminum alloys. Magnesium and magnesium alloys. Precious metals. Rear and radioactive metals. Chemical composition, structure and construction properties.

Literature
Recommended:
1. Б. Кочовски, Металургија легура обојених метала, Технички факултет Бор. (*in Serbian*)
2. М. Томовић, Ливење обојених и лаких метала, ТМФ, Београд, 1986. (*in Serbian*)
Supplementary:
1. Н. Д. Орлов, В. М. Чурсин, Цветноје литје, Металлургија , Москва, 1971. (*in Russian*)

Number of classes per week				Other classes:
Lectures: 3	Practicals: 1	Other forms of teaching: 2	Study research work:	

Methods of teaching
Lectures, practicals and other forms of teaching organized in interactive manner.

Grading system(max. number of points 100)

Pre-examination requirements	**Number of points**	**Final examination**	**Number of points**
Attendance and active participation	5	Written exam	20
Practicals	15	Oral exam	30
Preliminary examination	15		
Independent work	15		

Study program: Metallurgical Engineering

Level of study: Master Academic Studies

Course: METALLURGY OF CAST IRON AND STEEL

Lecturer: Dr. Srba Mladenović, associate professor

Course status: Elective course

ECTS: 8

Prerequisites: Necessary knowledge on cast iron and steel production

Course goals:
Basic knowledge on different steels.

Learning outcome:
Students will learn about properties and construction application of cast steels.

Course description:
Introduction. About steels. Cast steel. Definition. Carbon cast steel. Steels alloyed with silicon. Steels alloyed with manganese. Steels alloyed with nickel. Steels alloyed with chromium. Steels alloyed with vanadium. Steels alloyed with molybdenum. Steels alloyed with tungsten. Steels alloyed with copper. Chemical composition, structure and construction properties.

Literature
Recommended:
1. Б. Кочовски, Ливено гвожђе, Бор, 2006. (*in Serbian*)
2. Б. Кочовски, Металургија ливеног гвожђа и челика, 1996 ТФ Бор. (*in Serbian*)
Supplementary:
1. А. И. Плужникова, Производство стали с применением кислокода, Металлургија, Москва, 1976. (*in Russian*)

Number of classes per week				Other classes:
Lectures: 3	Practicals: 1	Other forms of teaching: 2	Study research work:	

Methods of teaching
Lectures, practicals and other forms of teaching organized in interactive manner.

Grading system(max. number of points 100)

Pre-examination requirements	**Number of points**	**Final examination**	**Number of points**
Attendance and active participation	5	Written exam	20
Practicals	15	Oral exam	35
Preliminary examination	10		
Independent work	15		

Study program: Metallurgical Engineering

Level of study: Master Academic Studies

Course: PROCESSING OF RARE AND PRECIOUS METALS

Lecturer: Dr. Dragoslav Gusković, full professor

Course status: Elective course

ECTS: 8

Prerequisites: Required knowledge on physical metallurgy and technologies for obtaining and processing rare metals

Course goals:
The course should enable the student to learn processes that take place in the liquid and solid state of precious and rare metals to make them easier to form in the required form.

Learning outcome:
The student should learn the processes of shaping metals in liquid and solid state and master the concrete technologies of melting, casting and plastic processing in order to be capable of efficient independent and team work in this field.

Course description:
Theoretical study
Melting of metals and alloys. Mold making. Casting in molds, sand, rubber and wax models. Cleaning and treatment of castings. Crystalline structure and defects. Plasticity of crystals. Strengthening curves. Plasticity of precious metals (gold, silver, platinum, palladium, iridium, osmium, ruthenium and rhodium). Plasticity of rare metals. Rolling. Drawing. Pressing. Forging. Deep drawing. Rotational forging of precious metals. Joining metals. Final treatment of precious and rare metals.
Practicals, Other forms of teaching, Study research work
Calculation and laboratory practicals follow lectures. Determining the proportion of components in the batch, determination of TMR of processing for specific alloy, calibrations.

Literature
Recommended:
1. П. Гертик, Племенити метали, својства, прерада, примена, Београд, 1997. (*in Serbian*)
2. Љ. Иванић, Ливарство, ТФ Бор, 2000. (*in Serbian*)
3. М. Пешић, Б. Мишковић, В. Миленковић, Прерада метала у пластичном стању, ТМФ, Београд, 1992. (*in Serbian*)
4. E. M. Savickij, G. S. Burhanov, Redkie metally i splavy, Nauka, Moskva, 1980. (*in Russian*)
5. E. Bkephol, Teorie und praxis das goldschmiedes, Veb Verlag, Leipzig, 1968.
Supplementary:
1. J. C. Wright, Technical Manual for Gold Jewellery, World bdl Council, London 1997.
2. B. Mališev, Serebro, Moskva, 1987. (*in Russian*)
3. C. Corti, R. Holliday, Gold, Science and Applications, CRC Press and W.G. Council, London, 2010.
4. D. Ott, Handbook on Casting and Other Defects in Gold Jewellery Manufacture, WGC, London, 1998.
5. П. Гертик, Уметничка обрада метала, МПМ, Београд, 2004. (*in Serbian*)

Number of classes per week				Other classes:
Lectures: 3	Practicals: 1	Other forms of teaching: 2	Study research work:	

Methods of teaching
Lectures and practicals are organized on an interactive principle, which besides classical lectures and presentations include discussions and active participation of students in all aspects of teaching.

Grading system(max. number of points 100)

Pre-examination requirements	**Number of points**	**Final examination**	**Number of points**
Attendance and active participation	5	Written exam	
Practicals	40	Oral exam	55
Preliminary examination			
Independent work			

Study program: Metallurgical Engineering

Level of study: Master Academic Studies

Course: THEORETICAL BASICS FOR CREATING A MASTER'S THESIS

Lecturer: Dr. Dragan Manasijević, full professor

Course status: Obligatory course

ECTS: 8

Prerequisites: Knowledge gained through obligatory and optional curriculum courses

Course goals:
Acquiring knowledge on how to define a research problem, its elaboration, writing and public presentation.

Learning outcome:
Allow students to independently apply the previously acquired knowledge to look at the structure of the problem and its systematic analysis in order to make conclusions about the possible directions of its solution. Through the use of literature alone, students expand their knowledge in studying different methods and papers that relate to similar issues, so the student develops the ability to conduct analysis and identifies issues within the course matter.

Course description:
Search for scientific literature. KOBSON. Index databases: Web of Science, SCOPUS. Publishers of scientific literature. ScienceDirect, Springer. Searching for domestic scientific literature. Serbian citation index. Research hypotheses and their testing. Methods of statistical analysis and processing of results using software packages: PSPP, QM and others. Multi-criteria decision making using the Decision Lab software package. Definition of the structure of the master's degree program. Literature rules and methods. Preparation of the public presentation of the master's degree program.

Literature
Recommended:
1. D. Manasijević, Teorijske osnove za izradu master rada, Tehnički fakultet u Boru, Bor 2014. (in Serbian)
Supplementary:
1. R. Carver, J. Nash, Doing data analysis with SPSS, Brooks / Cole Cengage Learning, 2009.
2. Articles in international journals from relevant fields.

Number of classes per week				Other classes:
Lectures: 2	Practicals: 2	Other forms of teaching:	Study research work: 11	

Methods of teaching
Lectures, group work, case studies, workshops.

Grading system(max. number of points 100)

Pre-examination requirements	**Number of points**	**Final examination**	**Number of points**
Attendance and active participation	10	Written exam	
Practicals		Oral exam	40
Preliminary examination	40		
Seminar paper	10		

Study program: Metallurgical Engineering
Level of study: Master Academic Studies
Course: PROFESSIONAL PRACTICE
Lecturers: Dr. Vesna Grekulović, assistant professor, Dr. Ljubiša Balanović, assistant professor and Dr. Aleksandra Mitovski, assistant professor
Course status: Obligatory course
ECTS: 6
Prerequisites: Certified 1st semester
Course goals: The aim of the professional practice is that, after finishing theoretical lectures, the student is practically acquainted with the application of theory in practice in the production conditions. In the course of professional practice, the student needs to study in more detail the production and processing technology of metals, and to compare it with theoretical knowledge from various courses examined and laid out.
Learning outcome: Students trained for the practical application of previously acquired theoretical and expert knowledge in solving specific practical engineering-technical problems in the production and processing of metals, as well as related areas.
Course description: It is formed for each student, especially in agreement with the management of the company in which professional practice is conducted, and in accordance with the needs of the profession for which the student is being trained. Professional practice program for each student is compiled by a full-time teacher-coordinator of professional practice with consulting other engaged teachers in the study program.

Number of classes per week	Other classes: 6

Methods of teaching Practical work or professional practice in an enterprise or institution is carried out according to a predefined program task that consists of data collection - measurement and analysis, in consultation with experts from the company where professional practice is being conducted and teacher-coordinator of professional practice. Upon completion of the professional practice, the student submits to the coordinator of the professional practice a written work with a description of the activities and activities that student performed during the professional practice. The teacher-coordinator of professional practice with his signature in the index confirms that the student has successfully completed the professional practice, which enables the student to verify the semester with other signatures. Professional practice is carried out within the framework of the following courses: Characterization of materials, Thermodynamics of materials, Structure and properties of precious metals, Continuous processes for obtaining wires and profiles, Processing of rare and precious metals, Metallurgy of non-ferrous metal alloys

Grading system(max. number of points 100)	
Professional practice attendance	50
Independent work	50

Study program: Metallurgical Engineering
Level of study: Master Academic Studies
Course: MASTER WORK
Lecturer: All teachers in the study program are potential mentors
Course status: Obligatory course
ECTS: 8
Prerequisites: Passed all exams and completed professional practice.
Course goals: The goal of working on master thesis and defending it is to show that by processing the practical task and its defense, student possesses a satisfactory ability to apply theoretical knowledge and practical skills in future engineering practice. In addition, through the completion of studies students are also trained in fast and adequate, economic, environmental and ethically based application of acquired knowledge and skills on specific, practical engineering examples in a company where he starts his professional career.
Learning outcome: By designing and defending master work, students are trained to manage the technological processes of obtaining and processing metals based on acquired theoretical and practical knowledge, realistically perceive the company's needs in all aspects, provide solutions for certain, real problems that occur in practice, and for continuing education on doctoral studies. Competencies acquired in this way include the ability of critical thinking, analysis, synthesis and decision making in real time. Specific skills - knowledge and skills in the practical application of theoretical knowledge to real problems in practice. This allows graduates engineers of metallurgy to be involved more quickly in solving real production problems at the beginning professional careers.
Course description: It is formulated for each student, especially within the existing areas of study program Metallurgical Engineering, in accordance to the given curriculum. Master work is the student's research work, during which he becomes acquainted with the methodology of research in the selected field in which he / she works. The student prepares master work in a form that contains the following chapters: Introduction, Theoretical part, Experimental part, Results and discussion, Conclusion, Literature overview. After completion of work, the student submits the completed written work in three copies and publicly defends it in front of a three-member commission composed of teachers from this study program.
Methods of teaching Mentor for working on the master work and defending it is determined based on the chosen area in which the student wants to do his work, he formulates a topic with tasks for master work. A student in consultation with a mentor independently solves the task given to him. After finishing the work and the consent of mentor that the work has been successfully completed, the student defends master work in front of a defense commission consisting of at least three teachers. Prerequisite for doing the master work are passed all the exams from the curriculum and professional practice carried out.

Grading system(max. number of points 100)	
Realization of the final work	70
Presentation and defense of final work	30