# Bogatenje mineralnih surovin in mehanska procesna tehnika Učni načrt predmeta/Course syllabus

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| Predmet: | Bogatenje mineralnih surovin in mehanska procesna tehnika |
| Course title: | Mineral Dressing and Mineral Processing |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Rudarstvo in geotehnologija (smer) | 1. letnik |  | izbirni |

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| Univerzitetna koda predmeta/University course code: | 0076008 |
| Koda učne enote na članici/UL Member course code: | 775 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 45 | 15 | 15 | 0 | 0 | 75 | 5 |

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| Nosilec predmeta/Lecturer: | Jože Kortnik |

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| Vrsta predmeta/Course type: | Izbirni / Elective |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
| Pogoj za kakovostno vključitev v delo je znanje študijske snovi iz predmetov: Matematike, Fizike, Kemije. | Proficiency in Mathematics, Physics, and Chemistry. |

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| Vsebina: | Content (Syllabus outline): |
| - KARAKTERIZIRANJE DISPERZNIH SISTEMOV poroznost, površina, oblika in velikost delcev, gostote - PROCESI VEČANJA POVRŠIN drobljenje, mletje, fizikalni zakoni, fenomenološki zakoni - PROCESI MANJŠANJA POVRŠIN aglomeriranje delcev, briketiranje, peletriranje - PROCESI LOČEVANJA DISPERZNIH SISTEMOV trdno-tekoče, trdno-plinasto, sejanje, klasiranje, zgoščevanje, filtriranje, odpraševanje - PROCESI MEŠANJA trdno-trdno, trdno-tekoče, tekoče-tekoče - VZORČENJE, SKLADIŠČENJE SIPKIH SNOVI - LASTNOSTI VHODNIH SUROVIN V BOGATILNIH PROCESIH - NAČINI LOČEVANJA V GRAVITACIJSKEM IN CENTRIFUGALNEM POLJU SIL: optično in ročno sortiranje, ločenje, ločevanje po gostoti: težke tekočine, tanek vodni sloj, pulzirajoči vodni tok - BOGATENJE V MAGNETNEM IN ELEKTRIČNEM POLJU - TEORIJA IN TEHNOLOGIJA FLOTIRANJA, vrste flotacij, uporaba - SPECIFIČNOSTI BOGATENJA ENERGETSKIH SUROVIN - premogov - SPECIFIČNOSTI BOGATENJA MINERALNIH SUROVIN - kovinskih in nekovinskih - POSEBNI POSTOPKI BOGATENJA IN PRIPRAVE MINERALNIH SUROVIN - SPECIFIČNOSTI BOGATENJA SEKUNDARNIH SUROVIN/URBANO RUDARJENJE 1. Vrste in tipi odlagališč, načrtovanje površinskih in podzemnih odlagališč, sanacija starih odlagališč; 2. Načrtovanje odlaganja odpadkov, načrtovanje sistemov za zajem in izrabo deponijskega plina, izcedne vode. 3. Vplivi odlagališč na okolje, varovanje in monitoring okolja: zemlja, voda in zrak; 4. Načrtovanje čistih tehnologij ponovne uporabe odpadkov (gradbenih odpadkov, rudarskih odpadkov, industrijskih odpadkov, itd.). | - CHARACTERIZATION OF DISPERSE SYSTEMS: porosity, specific surface, surface, shape and size of particles, density, - SURFACE SIZE ENLARGEMENT PROCEDURES: crushing, grinding, physical laws, - SURFACE SIZE REDUCTION PROCEDURES: particle agglomeration, briquettes, pellets, - DISPERSITY SYSTEMS SEPARATION PROCEDURES: solid-liquid, solid-gaseous, sowing, classification, solidification, filtration, dust reduction, - MIXING PROCEDURES: solid-solid, solid-liquid, liquid-liquid, - SAMPLING, FINE PARTICLES MAGAZINES, - MINERAL DRESSING ENTRANCE MATERIAL CHARACTERISTICS, - PHYSICAL ENRICHMENT: gravity, magnetic and electrostatic separation, - THEORY AND FLOTATION TECHNOLOGY: types of flotation, application - COAL PROCESSING, - INDUSTRIAL MINERALS PROCESSING, - PRECIOUS METALS PROCESSING, - HYDRO- AND BIOHYDROMETALLURGY, MINERAL AND MATERIAL DRESSING SPECIALITY, SPECIFICATION OF SECONDARY RAW MATERIALS DRESSING/URBAN MINING 1. Species and types of landfills, design of surface and underground landfills, rehabilitation of old landfills; 2. Planning of waste disposal, design of systems for capture and utilization of landfill gas, leachate. 3. Effects of landfills on the environment, protection and monitoring of the environment: soil, water and air; 4. Designing clean technologies for the reuse of waste (construction/demolition waste, mining waste, industrial waste, etc.). |

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| Temeljna literatura in viri/Readings: |
| **Knjige/Books:**  B.A. WILLS, T.J. NAPIER-MUNN (2008), *Will’s mineral processing technology – An introduction to the practical aspects of ore treatment and mineral recovery*, Elsevier, 7. izdaja, str. 444, B.A. Wills: MINERAL PROCESSING TECHNOLOGY, 6. izdaja, Butterworth Heineman, Oxford, 1997, 485 str. H. Schubert, AUFBEREITUNG FESTER MINERALISCHER ROHSTOFFE Bd 1-3 VEB Deutscher Verlag, Leipzig, 1989 ... in vse kasnejše izdaje. G.Tarjan, MINERAL PROCESSING, AKADEMIAI KIADO, Part 2, Budapest, 1986, 780 str. D. Ocepek, BOGATENJE MINERALNIH IN ENERGETSKIH SUROVIN, Univ. založba, Ljubljana, 1989, 350 str. J.Stražišar, MEHANSKA PROCESNA TEHNIKA I, NTF, 1996, 138 str. J.Stražišar, S.Knez, VAJE IN RAČUNSKI PRIMERI IZ MEHANSKE PROCESNE TEHNIKE, NTF, Ljubljana, 2001, 176 str. M. Rhodes, PRINCIPLES OF POWDER TECHNOLOGY, John Wiley&Sons, New York, 1993, 439 str.  **Revije/ Scientific magazines and scientific conference proceedings:**  Recycling, Waste management, Waste management and research; Zborniki posvetovanj, kongresov: International mineral proceessing congress. Publikacije so na voljo v knjižnicah UL in/ali v elektronski obliki preko spleta. |

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| Cilji in kompetence: | Objectives and competences: |
| Predmet nadgrajuje znanje študentov o konceptih, metodologiji in praktični uporabi mehanske procesne tehnike in bogatenja mineralnih surovin. Eksperimentalne vaje približajo študentom povezavo med teorijo in praktičnim pristopom k obravnavani snovi. Teoretične vsebine se povezujejo s praktičnimi primeri. Predmet daje tudi podlago za projektiranje disperznih sistemov v praksi, sposobnost sodelovanja pri razvojnem in raziskovalnem delu in prenašanju razvojnih in raziskovalnih dosežkov v prakso. | Upgrading knowledge on disperse systems. Acquiring knowledge and skills for designing, monitoring and evaluation of different disperse systems. Basic knowledge about disperse systems procedures to get familiar with basic elements of different mineral processing and dressing procedures. The course provides understanding of mineral dressing in practice, ability to cooperate in the development and research as well as transferring research to practice. The course deepens basic knowledge and brings to understanding mineral processing and mineral dressing, and provides competences for planning research work and bringing solutions to technical problems. |

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| Predvideni študijski rezultati: | Intended learning outcomes: |
| Znanje in razumevanje. | Knowledge and understanding. |

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| Metode poučevanja in učenja: | Learning and teaching methods: |
| Predavanja, individualno in skupinsko praktično delo. Poleg klasičnih predavanj v predavalnici z uporabo sodobnih avdio – vizualnih pripomočkov je študij organiziran še v obliki laboratorijskih vaj z namenom spoznavanja manuelnega dela kakor tudi analiz tehnoloških postopkov in metod projektiranja. Vaje se izvajajo individualno ali v manjših skupinah. | Lectures, individual and team practical work, field work. In addition to lectures with contemporary audio-visual systems, the also includes demonstration laboratory work with the purpose to get acquainted with manual practical work, as well as analyses used in technological procedures and design methods. |

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| Načini ocenjevanja: | Delež/Weight | Assessment: |
| Obveznost študenta je izdelava seminarske naloge, ki predstavlja samostojno raziskovalno delo študenta. Oceno sestavljajo rezultat ustnega izpita in zagovora seminarske naloge. | 0,00 % | Seminar work, written/oral exam; |

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| Reference nosilca/Lecturer's references: |
| 1. KORTNIK, Jože, ČERNEC, Franc, HRAST, Klementina. Paper sludge layer as low permeability barrier on waste landfills. Soil sediment contam. [Print ed.], 2008, vol. 17, no. 4, str. 381-392. JCR IF (2007): 0.646, SE (135/160), environmental sciences,  2. KORTNIK, Jože, HANN, Damjan. Analysis of process of removing impurities from calcium carbonate. *Physicochemical Problems of Mineral Processing*, ISSN 1643-1049, 2015, vol. 51, no. 2, str. 611-619. JCR, WoS IF (2015).  3. KORTNIK, Jože, Backfilling waste material composites environmental impact assessment, Journal of the South African Institute of Mining and Metallurgy, vol. 103, no. 6, 2003, str. 391-396. JCR IF: 0.061, SE (64/72), metallurgy & metallurgical engineering, x: 0.497, SE (16/20), mining & mineral processing, x: 0.406  4. KORTNIK, Jože, JOVIČIĆ, Vojkan, SPRUK, Simon. Stability assessment of paper sludge landfill cover barrier. International Conference Waste Management, Environmental Geotechnology and Global Sustainable Development - ICWMEGGSD'07 - GzO'07, August 28-30, 2007, Ljubljana, str. 34.  5. Predsednik organizacijskega odbora International Conference Waste Management, Environmental Geotechnology and Global Sustainable Development - ICWMEGGSD'07 - GzO'07, August 28-30, 2007, Ljubljana  6. KORTNIK, Jože, Izdelava ocene primernosti zasipa iz kompozitov odpadnih materialov. RMZ-mater. geoinviron., let. 49, št. 2, 2002, str. 217-227.  7. KORTNIK, Jože, Uporaba več pregradnega sistema pri izgradnji podzemnih odlagališč. RMZ-mater. geoenviron., let. 46, št. 2, 1999, str. 237-247. |

# Elastomehanika materialov Učni načrt predmeta/Course syllabus

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| Predmet: | Elastomehanika materialov |
| Course title: | Elastomechanics Materials |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 1. letnik |  | izbirni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 1. letnik |  | izbirni |

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| Univerzitetna koda predmeta/University course code: | 0076025 |
| Koda učne enote na članici/UL Member course code: | 783 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 45 | 30 | 0 | 0 | 0 | 75 | 5 |

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| Nosilec predmeta/Lecturer: | Primož Ziherl |

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| Vrsta predmeta/Course type: | Izbirni / Elective |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
| Vpis v letnik | General admission requirements |

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| Vsebina: | Content (Syllabus outline): |
| **I. Matematične osnove linearne teorije elastičnosti:** deformacijski in napetostni tenzor, ravnovesje sil, Hookov zakon, robni pogoji.  **II. Elastičnost izotropnih in anizotropnih materialov:** elastičnost izotropnih teles, elastičnost anizotropnih teles (kubični, nekubični kristali, polikristalni vzorci), anizotropno termično raztezanje.  **III. Plastična deformacija:** idealno plastično telo, rešitve izbranih plasto-elastičnih problemov, plastična anizotropija.  **IV. Teorija dislokacij:** geometrija, značaj in energija dislokacij, meja trdnosti kristalov, Burgersov vektor, energija vijačne dislokacije, sile na dislokacijo, mehanika dislokacij.  **V. Viskoelastičnost:** reološke lastnosti, kinematika in enačbe ravnovesja, konstitutivne enačbe, neelastični modeli in linearna viskoelastičnost.  **VI. Elastične nestabilnosti:** Eulerjeva nestabilnost, približne rešitve, izbrani primeri.  **VII. Nelinearna elastičnost:** nelinearna mehanika, hiperelastičnost, hipoelastičnost, glavne invariante, linearizacija. | **I: Mathematical foundations of linear theory of elasticity:** strain tensor and stress tensor, mechanical equilibrium, Hooke’s law, boundary conditions.  **II. Elasticity of isotropic and anisotropic materials:** elasticity of isotropic bodies, elasticity of anisotropic bodies (cubic and noncubic crystals, polycrystalline samples), anisotropic thermal expansion  **III. Plastic deformation:** ideal plastic body, solutions of selected plastic-elastic problems, plastic anisotropy.  **IV. Theory of dislocations:** geometry, nature, and energy of dislocations, yield strength of crystals, Burgers vector, energy of screw dislocation, forces on dislocation, mechanics of dislocations.  **V. Viscoelasticity:** rheological properties of materials, kinematics and mechanical equilibrium, inelastic models and linear viscoelasticity.  **VI. Elastic instabilities:** Euler instability, approximate solutions, selected examples.  **VII. Nonlinear elasticity:** nonlinear mechanics, hyperelasticity, hypoelasticity, invariants, linearization. |

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| Temeljna literatura in viri/Readings: |
| 1. I. Doghri, Mechanics of Deformable Solids: Linear, Nonlinear, Analytical and Computational Aspects (Springer, Berlin, 2000).  2. S. Timoshenko in J. N. Goodier, Theory of Elasticity (McGraw-Hill, New York, 1970).  3. J. P. Hirth in J. Lothe, Theory of Dislocations (McGraw-Hill, New York, 1992).  4. L. D. Landau in E. M. Lifshitz, Theory of Elasticity (Butterwoth Heinemann, Oxford, 1997).  5. N. Phan-Thien, Understanding Viscoelasticity (Springer, Berlin, 2002). |

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| Cilji in kompetence: | Objectives and competences: |
| poglobiti vpogled v elastomehaniko materialov | to extend previous knowledge and getting insight into elastomechanics of materials |

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| Predvideni študijski rezultati: | Intended learning outcomes: |
| Znanje in razumevanje. Obvladovanje matematičnih metod in konceptov v teoriji elastičnosti ter pregled nad zahtevnejšimi elementi teorije elastičnosti. Poglobljeno razumevanje pomena elastičnosti materialov na različnih področjih znanosti in tehnologije. | Knowledge and understanding. The student will master the mathematical methods and concepts in the theory of elasticity and acquire an overview of the advanced elements of the theory. Thus he or she will better appreciate the importance of elasticity of materials in various fields of science and technology. |

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| Metode poučevanja in učenja: | Learning and teaching methods: |
| Predavanja, seminarji, vaje in projekti, domače naloge in konzultacije. | Lectures, exercises, homework, consultations. |

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| Načini ocenjevanja: | Delež/Weight | Assessment: |
| Izpit pisni ali/in ustni. | 100,00 % | written and/or oral exam |

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| Reference nosilca/Lecturer's references: |
| 1. ATHANASOPOULOU, Labrini, ZIHERL, Primož. Phase diagram of elastic spheres. *Soft matter*, ISSN 1744-683X, 2017, vol. 13, no. 7, str. 1463-1471.  2. RIEST, Jonas, ATHANASOPOULOU, Labrini, EGOROV, Sergei A., LIKOS, Christos N., ZIHERL, Primož. Elasticity of polymeric nanocolloidal particles. *Scientific reports*, ISSN 2045-2322, nov. 2015, vol. 5, str- 15854-1-15854-12,  3. ŠIBER, Antonio, ZIHERL, Primož. Many-body contact repulsion of deformable disks. *Physical review letters*, ISSN 0031-9007. [Print ed.], 2013, vol. 110, no. 21, str. 214301-1-214301-5. |

# Fizika in kemija površin Učni načrt predmeta/Course syllabus

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| Predmet: | Fizika in kemija površin |
| Course title: | Physics and Chemistry Surfaces |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 1. letnik |  | izbirni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 1. letnik |  | izbirni |

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| Univerzitetna koda predmeta/University course code: | 0076026 |
| Koda učne enote na članici/UL Member course code: | 762 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 15 | 5 | 55 | 0 | 0 | 75 | 5 |

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| Nosilec predmeta/Lecturer: | Janez Kovač |

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| Vrsta predmeta/Course type: | Izbirni / Elective |

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| Jeziki/Languages: | Predavanja/Lectures: | Angleščina, Slovenščina |
|  | Vaje/Tutorial: | Angleščina, Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
| Univerzitetno znanje fizike in kemije ter analize strukture in sestave. | University level knowledge of physics, chemistry, analysis of structure and composition. |

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| Vsebina: | Content (Syllabus outline): |
| Karakterizacija površin trdnih snovi največkrat poteka v vakuumskih pogojih. Zato so študentom razložene fizikalno-kemijske osnove procesov, ki potekajo v vakuumu. Razložen jim je pojem trdne površine in razlika med atomi na površini in atomi v notranjosti materiala. Pokazana je povezava med površinsko energijo, fizikalnimi lastnostmi materialov in medatomskim potencialom. Študentje dobijo razlago o strukturi kristalnih površin, kristalografiji dvodimenzionalnih mrež in o označevanju površinskih struktur. Pri tem se jim razloži tudi relaksacija in rekonstrukcija površin. Defekti na površinah so razloženi z modelom teras, stopnic in kolen, posebej pa so obravnavane fazne transformacije na površinah. V tem sklopu predavanj so razložene metode za preiskavo struktur površin, kot so RHEED, AFM, STM in preiskave s sinhrotronsko svetlobo. V okviru predavanj so obravnavane tudi metode za kemijsko analizo površin, to so AES, XPS in SIMS, kakor tudi metode za preiskavo elektronskih lastnosti površin. Poseben poudarek je na profilni analizi tankih plasti in notranjih faznih mej. Študentje se seznanijo s procesi, ki potekajo na površinah, kot sta adsorpcija in desorpcija, pri čemer je natančno razložena razlika med fizisorpcijo in kemisorpcijo. Za moderne metalurške prevleke je pomembna rast tankih plasti iz parne faze. Posebej je obravnavana površinska difuzija in različni mehanizmi rasti tankih plasti, pojavi na mejni površini med podlago in tanko plastjo, heteroepiteksija in načini nukleacije tankih plasti, mrežna neskladnost in elastična deformacijska energija. Kemijska sestava notranjih mejnih površin ima močan vpliv na lastnosti tankoplastnih, kompozitnih in kosovnih materialov. Podrobneje je obravnavana segregacija na mejne površine, različne segregacijske izoterme, prosta segregacijska energija in kinetika segregacije. Študentje spoznajo nekatere metode za obdelavo površin in njihov tehnološki pomen. | Characterisation of surfaces of solid materials is usually performed in vacuum. Therefore students are introduced to physical-chemical processes in vacuum. The basic definition of the surface of the solid material is given and the differences between the atoms on the surface and atoms in bulk material are explained. The relations between the surface energy, physical properties of materials and inter-atomic potential are presented. Crystalline structures of surfaces, two-dimensional crystalline lattices and indexing of surface structures are explained. Relaxation and reconstruction processes on surfaces is presented. Surface defects are explained with a model of terraces, steps and kinks, and in particular phase transformations on the surfaces are demonstrated. Related to this subject, some analytical methods like RHEED, AFM, STM and methods based on synchrotron light are introduced. The methods for chemical analyses of surfaces, like AES, XPS and SIMS as well as methods for characterisation of electronic properties on surfaces are introduced. Special attention is paid on the analyses of depth distribution of elements in thin films and internal interfaces. Students are introduced to details of processes on surfaces like adsorption and desorption, and the difference between the physisorption and chemisorption. For modern metallurgical coatings the growth from the gas phase is of special importance. In particular the surface diffusion and different mechanisms of thin film growth, phenomena at substrate/film interfaces, heteroepitaxy and nucleation of thin films, lattice mismatch and elastic deformation energy are presented. Chemical composition of internal interfaces has an important influence on the properties of thin films, composites and bulk materials. Therefore the segregation at interfaces, different types of segregation isotherms, free segregation energy and kinetics of segregation are explained in details. Students learn about the most useful surface treatment methods and their applications. |

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| Temeljna literatura in viri/Readings: |
| 1.) V. Marinković, Mejne površine, NTF-OMM, Ljubljana, 1999.  2.) A. Zalar, Analiza strukture in sestave-analiza površin: zapiski  predavanj, Ljubljana, 2004, optični disk (CD-ROM), 20233.  3.) J.C. Vickerman, I.S. Gilmore, Surface Analysis, The Principal Techniques, John Wiley and Sons Ltd, West Sussex, UK, 2009  4) H. Lüth, Surfaces and Interfaces of Solid Materials, Springer-Verlag, 1998  5) S. Hofmann, Auger- and X-Ray Photoelectron Spectroscopy in Material Science, Springer-Verlag Berlin Heidelberg, 2013 |

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| Cilji in kompetence: | Objectives and competences: |
| Cilj je, da študenti po uspešnem zaključku obvladajo osnove fizikalnih in kemijskih procesov na površinah. Študenti naj bi bil sposoben prepoznati, kateri osnovni fizikalni in kemijski procesi potekajo pri praktičnih tehnoloških postopkih med obdelavo površin, opisati te procese in predvideti, kako vplivajo na obdelavo. Študenti naj bi bili po uspešnem zaključku sposobni kritično izbrati primerno metodo za karakterizacijo specifičnega problema povezanega s površinami, najti izvajalca tovrstne preiskave, predvideti obseg preiskave in interpretirati dobljene rezultate. Študenti naj bi bili po uspešnem zaključku sposobni izbrati in oceniti primernost ter smotrnost izbire tehnološkega specifičnega postopka za obdelavo površin. | After the course the students should be able to understand and describe basic physical and chemical processes at solid surfaces. Students should be able to identify which basic physical and chemical processes take place during specific technological surface treatment, they should be able to describe these processes and predict their effects on treated surface. Students should be able to choose critically the proper analytical method for specific surface related problem, find the available analytical service, predict the extent of analysis and interpret the obtained results. Student should be able to choose and critically estimate the suitability and efficiency of specific treatment process for surface related problems. |

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| Predvideni študijski rezultati: | Intended learning outcomes: |
| Znanje in razumevanje:  Študenti spoznajo metode, s katerimi preiskujemo sestavo, kemijsko stanje in geometrijsko razporeditev atomov ter elektronsko strukturo površin trdnih snovi. Študenti osvojijo osnove preiskovalnih metod za ugotavljanje sestave površin, to so spektroskopija Augerjevih elektronov (AES), rentgenska fotoelektronska spektroskopija (XPS), masna spektroskopija sekundarnih ionov (SIMS), nadalje metode za strukturno in mikroskopsko preiskavo površin, kot so uklon nizkoenergijskih elektronov (LEED), uklon visokoenergijskih elektronov (RHEED), vrstična tunelska mikroskopija (STM), mikroskopija na atomsko silo (AFM) in tunelska mikroskopija (STM) ter metode za preiskavo elektronske strukture površin. Študenti praktično uporabljajo v laboratoriju nekatere od gornjih metod, praktično izvedejo kvantifikacijo rezultatov, pripravijo poročilo oziroma seminar o izvedenih laboratorijskih preiskavah. Pridobijo znanje o površinskih kristalografskih strukturah, termodinamskih lastnostih površin, o elektronski strukturi površin, o izstopnem delu elektronov in posebnostih, ki nastanejo ob prisotnosti adsorbata na površinah kristalov. Študenti spoznajo realne površine s površinskimi defekti in faznimi transformacijami na površinah. Pridobijo znanje o fizisorpciji in kemosorpciji ter s tem v zvezi tudi označevanje adsorbatnih struktur. Pridobijo znanje o rasti tankih plasti iz parne faze, površinski difuziji, o pojavih na mejni površini med podlago in tanko plastjo, o mehanizmu rasti tankih plasti, načinu nukleacije in segregacije na mejnih površinah in o mejnih površinah v trdninah. Študent spozna, da imajo proste površine trdnih snovi, notranje mejne površine in tanke plasti drugačne fizikalno-kemijske lastnosti kot notranjost materialov. Spozna in zna izbrati preiskovalne metode za ugotavljanje sestave, kemijskega stanja elementov na površinah in elektronskih lastnosti ter kristalne strukture površin. Usposobi se za spremljanje različnih procesov, ki potekajo na površinah trdnih snovi. Študentje spoznajo metode za obdelavo površin in njihov tehnološki pomen. Študentje pridobijo osnovno znanje s področja fizikalno-kemijskih osnov vakuuma, ki je nujno potrebno za razumevanje delovanja analitskih metod za preiskavo površin. | Knowledge and understanding:  Students gain knowledge about characterisation of composition, chemical state, geometrical distribution of atoms and electronic structure of solid surfaces. The lear abot modern surface analytical methods for characterisation of composition like Auger electron spectroscopy (AES), X-ray photoelectron spectroscopy (XPS), secondary ion mass spectroscopy (SIMS), about methods for structural and microscopic investigation of surfaces, like low electron energy diffraction (LEED), reflective high energy electron diffraction (RHEED), scanning tunnelling microscopy (STM) and atomic force microscopy (AFM) and methods for analyses of electronic structure. In the laboratory students practically learn how to use the surface analytical methods, they analyse the surfaces, elaborate obtained data and prepare report. Students gain knowledge about surface crystallographic structures, thermodynamic properties of surfaces, surface work function and changes in the presence of adsorbates on the crystal surfaces. Students learn about real surfaces with surface defects and phase transitions on surfaces. They acquire knowledge about physisorption and chemisorption and the indexing of adsorbate structures on the surfaces. Students acquire knowledge on the growth of thin films from the gas phase, surface diffusion, processes at thin film/substrate interfaces, mechanisms of thin film growth, nucleation and segregation at surfaces and internal interfaces. Students recognize that free solid surfaces, internal interfaces and thin films have different physical and chemical properties compared to bulk solid materials. Students learn to choose an appropriate analytical method for characterisation of composition, chemical state of elements on surfaces, electronic properties and crystalline structure of solid surfaces, and how to follow different processes at solid surfaces, which affect the chemical, electronic and mechanical properties of materials. Students learn about the most useful surface treatment methods and their applications. Students gain knowledge about physical and chemical processes in vacuum, which is necessary for understanding the principles of analytical methods |

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| Metode poučevanja in učenja: | Learning and teaching methods: |
| Uvodna predavanja,  Priprava, predstavitev in zagovor seminarske naloge,  Praktična uporaba metod pri raziskovalnem delu v laboratoriju  Konzultacije | Lectures,  Preparation and presentation of a seminar,  Application of surface analyses in research work in the laboratory  Consultancy |

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| Načini ocenjevanja: | Delež/Weight | Assessment: |
| Ustni izpit | 50,00 % | Oral examination |
| Priprava, predstavitev in zagovor seminarske in projektne naloge. | 50,00 % | Presentation of seminar |

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| Reference nosilca/Lecturer's references: |
| 1. J. Kovač, P. Panjan, A. Zalar, XPS analysis of WxCy thin films prepared by sputter deposition. Vacuum. 82, (2007) 2, 150-153.   J. Kovač, M. Bizjak, B. Praček, A. Zalar, Auger electron spectroscopy depth profiling of Fe-oxide layers on electromagnetic sheets prepared by low temperature oxidation, Appl. Surf. Sci., 253 (2007) 4132-4136.  U. Tiringer, J. Kovač, I. Milošev, Effects of mechanical and chemical pre-treatments on the morphology and composition of surfaces of aluminium alloys 7075-T6 and 2024-T3, Corrosion science, 2017, vol. 119, str. 46-59  G. Žerjav, M.S. Arshad, P. Djinović, I. Junkar, J. Kovač, J. Zavašnik, A. Pintar, Improved electron-hole separation and migration in anatase TiO2 nanorod/reduced graphene oxide composites and their influence on photocatalytic performance, Nanoscale, 2017, vol. 9, iss. 13, str. 4578-4592  M. Bizjak, B. Karpe, G. Jakša, J. Kovač, Surface precipitation of chromium in rapidly solidified CuCr alloys, Applied Surface Science, 2013, vol. 277, 83-87,  P. Močnik, T. Kosec, J. Kovač, M. Bizjak, The effect of pH, fluoride and tribocorrosion on the surface properties of dental archwires. Materials science & engineering. C, Materials for biological applications, Apr. 2017, 1-11. |

# Fizika trdne snovi Učni načrt predmeta/Course syllabus

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| Predmet: | Fizika trdne snovi |
| Course title: | Physics of Solid Materials |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 1. letnik |  | izbirni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 1. letnik |  | izbirni |

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| Univerzitetna koda predmeta/University course code: | 0076027 |
| Koda učne enote na članici/UL Member course code: | 781 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 45 | 30 | 0 | 0 | 0 | 75 | 5 |

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| Nosilec predmeta/Lecturer: | Janez Dolinšek |

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| Vrsta predmeta/Course type: | Izbirni / Elective |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
| Vpis v letnik. | General admission requirements. |

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| Vsebina: | Content (Syllabus outline): |
| 1. Struktura snovi: gradniki in interakcije - merilo urejenosti, kristali, kvazikristali, fraktali, stekla, mehke snovi 2. Teorija elektronov v kristalih: model prostih elektronov, transportne lastnosti prevodniških elektronov, energijski pasovi, Fermijeva površina, gostota stanj, plazemske oscilacije 3. Polprevodniki: čisti in dopirani polprevodniki, transportne lastnosti polprevodnikov 4. Mrežna nihanja: enodimenzionalna veriga identičnih atomov, veriga atomov dveh vrst (optična akustična veja), posplošitev na tri dimenzije, specifična toplota 5. Diamagnetizem in paramagnetizem: izvor magnetnih momentov, Larmorjev diamagnetizem, paramagnetizem prostih magnetnih momentov in prevodniških elektronov, Hundova pravila 6. Magnetne strukture: izmenjalna sklopitev, Weissova teorija feromagnetizma, različni tipi magnetnih struktur, feromagnetne domene, histereza 7. Superprevodnost: termodinamika superprevodnega stanja, fenomenološka teorija superprevodnikov tipa I in II, enačba Londona, makroskopski kvantni pojavi in visokotemperaturni superprevodniki 8. Nanosistemi: dvodimenzionalni elektronski plin, mezoskopske elektronske strukture 9. Defekti kristalne mreže: termodinamika točkastih defektov, električna prevodnost ionskih kristalov, barvni centri, polaroni in excitoni, dislokacije 10. Površine: struktura površin, fenomenologija moženja. | 1.Structure of matter 2.Electron theory of crystals 3.Semiconductors 4.Lattice vibrations 5.Diamagnetism and paramagnetism 6.Magnetic ordering 7.Superconductivity 8.Nanoscale systems 9.Defects in crystals 10.Surfaces |

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| Temeljna literatura in viri/Readings: |
| 1. Solid State Physics, J.R. Hook in H.E. Hall, The Manchester Physics Series, John Wiley & Sons (1991).  2. Solid State Physics, N.W. Ashcroft in N.D. Mermin, ed. D.G. Crane, Sunders College, Philadelphia.  3. Physics of Materials, Yves Quere Gordon and Beach Science Publishers (1998);  4. Solid state Physics, Gerald Burns, Academic Press, INC. (1990). |

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| Cilji in kompetence: | Objectives and competences: |
| Pridobiti znanje o fiziki materialov. | Acquiring knowledge on physics of materials. |

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| Predvideni študijski rezultati: | Intended learning outcomes: |
| Znanje in razumevanje: Razumevanje osnovnih fizikalnih lastnosti materialov v različnih faznih stanjih, s povdarkom na novih materialih | Knowledge and understanding: Understanding of basic physical properties of materials and their different phases, with the emphasis on novel materials. |

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| Metode poučevanja in učenja: | Learning and teaching methods: |
| Predavanja, seminarji, vaje in projekti, domače naloge in konzultacije. | Lectures, exercises, homework, consultations. |

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| Načini ocenjevanja: | Delež/Weight | Assessment: |
| Seminarska naloga, ustni izpit. | 100,00 % | Seminar and oral exam. |

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| Reference nosilca/Lecturer's references: |
| 1. ELECTRICAL AND THERMAL TRANSPORT PROPERTIES OF ICOSAHEDRAL AND DECAGONAL QUASICRYSTALS  J. Dolinšek, Chem. Soc. Rev. 41, 6730-6744 (2012)  2. DISCOVERY OF A SUPERCONDUCTING HIGH-ENTROPY ALLOY, P. Koželj, S. Vrtnik, A. Jelen, S. Jazbec, Z. Jagličić, S. Maiti, M. Feuerbacher, W. Steurer, J. Dolinšek  Phys. Rev. Lett. **113**, 107001 (2014)  3. COMPLEX MAGNETISM OF Ho-Dy-Y-Gd-Tb HEXAGONAL HIGH-ENTROPY ALLOY, J. Lužnik, P. Koželj, S. Vrtnik, A. Jelen, Z. Jagličić, A. Meden, M. Feuerbacher, J. Dolinšek  Phys. Rev. B **92**, 224201 (2015)  4. SCHOTTKY EFFECT IN THE *i*-Zn-Ag-Sc-Tm ICOSAHEDRAL QUASICRYSTAL AND ITS 1/1 Zn-Sc-Tm APPROXIMANT, S. Jazbec, S. Kashimoto, P. Koželj, S. Vrtnik, M. Jagodič, Z. Jagličić, J. Dolinšek, Phys. Rev. B **93**, 054208 (2016)  5. DISORDERED FERROMAGNETIC STATE IN THE Ce-Gd-Tb-Dy-Ho HEXAGONAL HIGH-ENTROPY ALLOY, S. Vrtnik, J. Lužnik, P. Koželj, A. Jelen, J. Luzar, Z. Jagličić, A. Meden, M. Feuerbacher, J. Dolinšek, J. Alloys Compd. **742**, 877-886 (2018) |

# Fizikalna metalurgija Učni načrt predmeta/Course syllabus

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| Predmet: | Fizikalna metalurgija |
| Course title: | Physical Metallurgy |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 1. letnik |  | izbirni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 1. letnik |  | izbirni |

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| Univerzitetna koda predmeta/University course code: | 0076028 |
| Koda učne enote na članici/UL Member course code: | 760 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 15 | 30 | 0 | 0 | 30 | 75 | 5 |

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| Nosilec predmeta/Lecturer: | Boštjan Markoli |

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| Vrsta predmeta/Course type: | Izbirni / Elective |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
| Zaključen dodiplomski študij z oceno 8 in več smeri Metalurgija in materiali, Fizika, Kemija | Completed undergraduate studies in either metallurgy, materials, mathematics physics, chemistry or chemical technology with grade average 8 or higher |

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| Vsebina: | Content (Syllabus outline): |
| Vsebina predmeta obsega izbrana poglavja s področja plastične deformacije kovin, ter difuzijske transformacije in brezdifuzijske transformacije v trdnih snoveh, s poudarkom na kovinskih materialih. Plastična deformacija kovin: deformacija kovinskih kristalov: deformacija k. pl. c. kristalov, deformacija k. pr. c. kristalov, deformacija heksagonalnih kristalov; teorija deformacijskega utrjevanja; trdne raztopine; deformacija kristalov s sekundarno fazo; kristalne meje in plastična deformacija. Difuzijske transformacije v trdih snoveh: homogena in heterogena transformacija; rast precipitatov; izločevanje v toplotno utrjevalnih zlitinah, kinetika transformacije -TTT diagrami. Izločanje ferita iz avstenita, celularno izločanje, eutektoidne transformacije; masivne transformacije; primeri. Brezdifuzijske transformacije v trdnih snoveh: Značilnosti brezdifuzijskih transformacij, teorija martenzitnih transformacij; | Selected chapters from topics on plastic deformation of metals and diffusional and diffusionless transformations in solids. Plastic deformation of metals: Deformation of f.c.c.crystals. Deformation of b.c.c. crystals. Deformation of hexagonal crystals. Theories of work hardening of metals. Deformation of solid solution crystals. Deformation of crystals containing a second phase. Grain boundaries and plastic deformation. Diffusional transformations in solids: Homogeneous and heterogeneous nucleation in solids. Precipitate growth. Precipitation in age hardening alloys. Transformation kinetics-TTT diagrams. Precipitation of ferrite from austenite. Cellular precipitation. Eutectoid transformations. Massive transformations. Case studies. Diffusionless Transformations: characteristics of diffusionless transformations. Theories of martesite transformations. |

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| Temeljna literatura in viri/Readings: |
| Honeycombe, R.W.K., The plastic deformation of metals(Edward Arnold ,London,1984)  Porter, D.A. and Easterling, K.E., Phase transformations in metals and alloys (Chapman&Hall, London 1993)  Hosford, W.F., Physical metallurgy, (Boca Raton, FL:CRC Press,2005)  Verhoeven, J.D., Fundamentals of physical metallurgy (John Wiley, New york, 1975)  Marinković, V., Fizikalna metalurgija II, (OMM,NTF,UL, Ljubljnana,1999) |

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| Cilji in kompetence: | Objectives and competences: |
| Namen predmeta je poglobljeno poznavanje problemov s področja kovinskih materialov, med katerimi sta pomembna predvsem fazne transformacije v trdnem in deformacijsko utrjevanje. Detajlno poznavanje teh problemov je pomembno tudi iz praktičnega vidika, ker omogoča načrtovanje in kontrolirano vodenje izdelave in predelave različnih kovinskih materialov. Vsebina predmeta v osnovi je poznana študentom smeri Materiali in metalurgija in gre v tem primeru za nadgradnjo. Vsebina predmeta je manj poznana študentom drugih smeri. | The objective of the course is expand knowledge in the field of metallic materials (e.g. phase transformation in solid state and deformation hardening). In-depth knowledge of these topics is important to be able to deal with practical applications in planning and monitoring the production and processing of various metallic materials. The content of the course is well known to graduates in metallurgy however, it is less known to other students. |

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| Predvideni študijski rezultati: | Intended learning outcomes: |
| Znanje in razumevanje. | Knowledge and understanding |

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| Metode poučevanja in učenja: | Learning and teaching methods: |
| Predavanja, izdelava seminarskega dela | Lectures, seminar work |

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| Načini ocenjevanja: | Delež/Weight | Assessment: |
| Ocena seminarskega dela | 50,00 % | Seminar assessment |
| Zagovor seminarskega dela | 50,00 % | Oral defence of seminar |

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| Reference nosilca/Lecturer's references: |
| |  | | --- | | 1. B. Markoli, S. Spaić. Effect of tempering on the microstructure and hardness of ledeburitic chromium steel X155Crvmo12.1, Z. Met.kd. 2007, Vol. 98, No.2, str.150-154  2. ŠTURM, Sašo, ŽUŽEK ROŽMAN, Kristina, MARKOLI, Boštjan, SPYROPOULOS ANTONAKAKIS, Nikolaos, SARANTOPOULOU, Evangelia, KOLLIA, Zoe, CEFALAS, Alciviadis-Constantinos, KOBE, Spomenka. Pulsed-laser fabrication of gas-filled hollow CoPt nanospheres. *Acta materialia*, ISSN 1359-6454. 2013, vol. 61, no. 61, str. 7924-7930  3. MARKOVIĆ, Ivana, NESTOROVIĆ, Svetlana, MARKOLI, Boštjan, PREMOVIĆ, Milena, MLADENOVIĆ, Srba. Study of anneal hardening in cold worked Cu-Au alloy. *Journal of alloys and compounds*, ISSN 0925-8388. [Print ed.], 2016, vol. 658, str. 414-421. | |

# Funkcionalni materiali Učni načrt predmeta/Course syllabus

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| Predmet: | Funkcionalni materiali |
| Course title: | Functional Materials |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 1. letnik |  | izbirni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 1. letnik |  | izbirni |

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| Univerzitetna koda predmeta/University course code: | 0076029 |
| Koda učne enote na članici/UL Member course code: | 766 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 45 | 30 | 0 | 0 | 0 | 75 | 5 |

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| Nosilec predmeta/Lecturer: | Janez Dolinšek |

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| Vrsta predmeta/Course type: | Izbirni / Elective |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
| Vpis v letnik. | General admission requirements |

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| Vsebina: | Content (Syllabus outline): |
| I. Elektronski materiali in električne lastnosti 1. Električna prevodnost kovin in zlitin 2. Polprevodniki 3. Električna prevodnost keramike in polimerov 4. Dielektriki 5. Feroelektrični materiali 6. Piezoelektričnost II. Toplotni prevodniki in izolatorji 1. Toplotna kapaciteta 2. Termično raztezanje 3. Toplotna prevodnost 4. Termične napetosti v materialih III. Termoelektrični materiali 1. Seebeckov pojav 2. Termoelektrična napetost v kovinah 3. Termoelektrična napetost v polprevodnikih 4. Termoelektrični senzorji IV. Magnetni materiali 1. Diamagnetizem in paramagnetizem 2. Feromagnetizem 3. Antiferomagnetizem in ferimagnetizem 4. Temperaturna odvisnost magnetnih lastnosti 5. Magnetne domene in histerezna zanka 6. "Mehki" magnetni materiali 7. "Trdi" magnetni materiali 8. Magnetni spomin V. Superprevodniki 1. Kritična temperatura 2. Meissnerjev efekt 3. Kritično magnetno polje, kritični tok 4. Specifična toplota 5. Energijska vrzel v gostoti stanj prevodniških elektronov 6. Josephsonov efekt 7. Superprevodniki I. in II. vrste 8. Superprevodni materiali 9. Visokotemperaturni superprevodniki 10. Organski superprevodniki 11. SQUID merilnik za izjemno majhna magnetna polja VI. Materiali za optično uporabo 1. Optične lastnosti kovin 2. Optične lastnosti nekovin 3. Uporaba optičnih materialov 3.1 Svetlikanje (luminescenca) 3.2 Fotoprevodnost 3.3 Laserji 3.4 Optična vlakna in komunikacije VII. Kvazikristali 1. Koncept prepovedanih kristalnih simetrij 2. Kvaziperiodične kristalne mreže 3. Sinteza kvazikristalov 4. Kvazikristalne družine 5. Električne lastnosti 6. Termične in termoelektrične lastnosti 7. Magnetne lastnosti 8. Trdota, trenje, omočljivost površine, hladno varjenje, mehanske lastnosti 9. Kvazikristalne tanke plasti VIII. Mikro- in nanocevke ter žice 1. Struktura 2. Sinteza s kemijskimi reakcijami 3. Mehanske lastnosti 4. Električne lastnosti 5. Uporaba za izboljšanje mehanske trdnosti kompozitnih materialov IX. Materiali na osnovi ogljika 1. Diamant 2. Grafit 3. Fulereni 4. Ogljikove nanocevke X. Materiali za skladiščenje vodika 1. Gorivne celice 2. Kovinski hidridi 3. Skladiščenje vodika v kovinah | I. Electronic materials and electrical properties II. Thermal conductors and insulators III. Thermoelectric materials IV. Magnetic materials V. Superconductors VI. Optical materials VII. Quasi crystals VIII. Micro- and nanotubes and wires IX. Carbon-based materials X. Hydrogen-storage materials |

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| Temeljna literatura in viri/Readings: |
| 1. Materials Science and Engineering: An Introduction; 6th edition, W. D. Callister, Jr. (John Wiley & Sons, Inc., 2003)  2. Engineering Materials Science; M. Ohring (Elsevier, 1995) 3. Quasicrystals – A Primer; 2nd edition, C. Janot (Clarendon Press, Oxford, 1994) |

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| Cilji in kompetence: | Objectives and competences: |
| pridobiti znanje o funkcionalnih materialih | gaining knowledge on functional materials |

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| Predvideni študijski rezultati: | Intended learning outcomes: |
| Znanje in razumevanje fizikalnih lastnosti modernih funkcionalnih materialov. | Knowledge and understanding of physical properties of modern functional materials. |

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| Metode poučevanja in učenja: | Learning and teaching methods: |
| Predavanja, seminarji, vaje in projekti, domače naloge in konzultacije. | Lectures, exercises, homework, consultations |

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| Načini ocenjevanja: | Delež/Weight | Assessment: |
| Izpit pisni ali/in ustni. | 100,00 % | written and/or oral exam |

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| Reference nosilca/Lecturer's references: |
| 1. DOLINŠEK, Janez, VRTNIK, Stanislav, KLANJŠEK, Martin, JAGLIČIĆ, Zvonko, SMONTARA, Ana, SMILJANIĆ, Igor, BILUŠIĆ, Ante, YOKOYAMA, Y., INOUE, Akihisa, LANDAURO, C. V. Intrinsic electrical, magnetic, and thermal properties of single-crystalline Al[sub](64)Cu[sub](23)Fe[sub](13) icosahedral quasicrystal: experimental and modeling. Phys. rev., B, Condens. matter mater. phys., 2007, vol. 76, no. 5, str. 054201-1-054201-9.  2. DOLINŠEK, Janez, SLANOVEC, Jernej, JAGLIČIĆ, Zvonko, HEGGEN, M., BALANETSKYY, S., FEUERBACHER, M., URBAN, K. Broken ergodicity, memory effect, and rejuvenation in Taylor-phase and decagonal Al[sub]3(Mn, Pd, Fe) complex intermetallics. Phys. rev., B, Condens. matter mater. phys., 2008, vol. 77, no. 6, str. 064430-1-064430-18.  3. DOLINŠEK, Janez, KOMELJ, Matej, JEGLIČ, Peter, VRTNIK, Stanislav, STANIĆ, Denis, POPČEVIĆ, P., IVKOV, Jovica, SMONTARA, Ana, JAGLIČIĆ, Zvonko, GILLE, Peter, GRIN, Yuri. Anisotropic magnetic and transport properties of orthorhombic Al[sub](13)Co[sub]4. Phys. rev., B, Condens. matter mater. phys., 2009, vol. 79, no. 18, str. 184201-184201-12. |

# Heterogena ravnotežja v procesni tehniki kovinskih materialov Učni načrt predmeta/Course syllabus

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| Predmet: | Heterogena ravnotežja v procesni tehniki kovinskih materialov |
| Course title: | Heterogeneous Equilibria in Process Engineering of Metallic Materials |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 1. letnik |  | izbirni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 1. letnik |  | izbirni |

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| Univerzitetna koda predmeta/University course code: | 0076030 |
| Koda učne enote na članici/UL Member course code: | 769 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 30 | 15 | 30 | 0 | 0 | 75 | 5 |

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| Nosilec predmeta/Lecturer: | Jožef Medved, Maja Vončina |

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| Vrsta predmeta/Course type: | Izbirni / Elective |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina, Angleščina |
|  | Vaje/Tutorial: | Slovenščina, Angleščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
| Opravljen magistrski študij ter poznavanje termodinamike in kinetike materialov, procesne tehnike jekla in neželeznih kovin, fizikalne metalurgije in modeliranja. | Completed master’s degree and acquired knowledge on thermodynamics and kinetics of materials, process techniques of steel and nonferrous metals, physical metallurgy and modelling. |

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| Vsebina: | Content (Syllabus outline): |
| - Termodinamika materialov: metode reševanja in prikaza končnega ravnotežnega ali neravnotežnega faznega stanja heterogenih sistemov.  - Reakcijska kinetika: mehanizmi heterogenih reakcij, določevanje poteka reakcije in numeričnega modela vrednotenja.  - Procesno modeliranje: formulacija, rešitev in vrednotenje, numerične metode in tehnike modeliranja in simuliranja procesne tehnike materialov.  - Metode preiskovanja heterogenih reakcija: klasične laboratorijske metode (termične analize, določevanje energija in aktivnosti,…) ter tehnološke laboratorijske in industrijske metode simuliranja procesov.  - Sistemi reakcij: transport snovi, fazne premene, modeli heterogenih sistemov, obdelava posebnih procesov proizvodnje in procesiranja materialov (kot so: razvoj materiala, reakcije med izdelavo zlitine, visokotemperaturna oksidacija,…).  - Seminarska naloga.  - Projektno delo. | - Thermodynamics of materials: methods of solving and presentation of final equilibrium and nonequilibrium phase state of heterogeneous systems. - Reaction kinetics: the mechanisms of heterogeneous reactions, determination of the course of the reactions and evaluation of numerical models.  - Process modelling: formulation, solution and evaluation of numerical method, modelling technique and simulation of process techniques of materials.  - The research methods for heterogeneous reactions: traditional laboratory methods (thermal analyses, determination of energies and activities …) and technological laboratory and industrial methods of simulation of the processes.  - Reaction systems: transport of materials, phase transformations, models of heterogeneous reaction systems, treatment of special production processes (i.e.: development of the material, reactions during the production of alloys, high temperature oxidation…).  - Seminar.  - Project work. |

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| Temeljna literatura in viri/Readings: |
| |  | | --- | | 1. R. DeHoff. Thermodynamics in Materials Science, CRC Press, Taylor & Francis Group, 2006.  2. M. Hillert. Phase equilibria, phase diagrams and phase transformations, Cambridge university press, 1998.  3. P. Gabbott, Principles and Applications of Thermal Analysis. Blackwell Publishing, 2006.  4. R. O’Hayre, MATERIALS KINETICS FUNDAMENTALS, John Wiley & Sons, 2015.  5. D. J. Young, High Temperature Oxidation and Corrosion of Metals, Elsevier, 2016.  6. S. Seetharaman Fundamentals of metallurgy. Woodhead Publishing, 2005.  7. Specialirizirane monografije za posamezna področja ter novejši članki iz znanstvenih revij. | |

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| Cilji in kompetence: | Objectives and competences: |
| Poglobljeno spoznavanje izbranih raziskovalnih področij termodinamičnega modeliranja materialov v ravnotežnem in neravnotežnem stanju ter heterogena reakcijska kinetika. Cilj premeta je simuliranje, vodenje in kontrola procesnih aplikacij predvsem na področju izdelave kovinskih, nekovinskih anorganskih ter sestavljenih materialov. Kandidat se seznani z modernimi pristopi in metodami termodinamičnega in kinetičnega modeliranja heterogenih procesov načrtovanja, izdelave in obdelave materialov. | In-depth knowledge of selected research areas of thermodynamic modelling of materials in equilibrium and non-equilibrium states and heterogeneous reaction kinetics. The aim of the course is to simulate, manage and control process applications, especially in the field of manufacturing metallic, non-metallic, inorganic and composite materials. The candidate becomes familiar with modern approaches and methods of thermodynamic and kinetic modelling of heterogeneous processes of design, production and processing of materials. |

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| Predvideni študijski rezultati: | Intended learning outcomes: |
| Pri predmetu Heterogena ravnotežja v procesni tehniki kovinskih materialov se študent nauči obravnavati večkomponentne in večfazne sisteme na področju anorganskih materialov. Seznani se z temeljnimi orodij za termodinamično in kinetično modeliranje ter karakterizacijo, ki jih aplikativno uporabi pri projektnem delu izdelave novega materiala. | In the course Heterogeneous equilibria in the process engineering of metallic materials, the student learns to deal with multicomponent and multiphase systems in the field of inorganic materials. Familiarize yourself with the basic tools for thermodynamic and kinetic modelling and characterization, which he applies in the project work of manufacturing a new material. |

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| Metode poučevanja in učenja: | Learning and teaching methods: |
| Uvodna predavanja, priprava, predstavitev in zagovor seminarske naloge, projektno delo v Laboratoriju za termodinamiko in kinetiko materialogv ter praktična uporaba metod pri raziskovalnem delu. | Introduction course, preparing and presentation of seminar, working on a project in the Laboratory for thermodynamics and kinetics of the materials, and practical application of the methods in student research work. |

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| Načini ocenjevanja: | Delež/Weight | Assessment: |
| Projekt in seminar | 40,00 % | Project and seminar |
| Ustni izpit | 60,00 % | Oral exam |

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| Reference nosilca/Lecturer's references: |
| **Prof. dr. Jožef Medved**   1. MEDVED, Jože, PIRNAT, Miran, MRVAR, Primož. Fazna ravnotežja v aluminijevih livarskih zlitinah v odvisnosti od vsebnosti Si in Fe = Phase equilibrium in aluminium cast alloys depending on Si and Fe content. *Livarski vestnik : glasilo Društva livarjev Slovenije*, ISSN 0024-5135, 2015, letn. 62, št. 2, str. 99-10*6.* 2. MEDVED, Jože, GAIANI, Silvia, VONČINA, Maja, MRVAR, Primož, TISU, Robert. Visokotemperaturna oksidacija Ti-materialov = High temperature oxidation of Ti materials. *Livarski vestnik*, ISSN 0024-5135, 2012, letn. 59, št. 3, 2015, str. 130-136. 3. MEDVED, Jože, MRVAR, Primož, VONČINA, Maja. Oxidation resistance of cast magnesium alloys. *Oxidation of metals*, ISSN 0030-770X, 2009, vol. 71, no. 5/6, str. 257-270. 4. MEDVED, Jože, KORES, Stanislav, VONČINA, Maja. Development of innovative Al-Si-Mn-Mg alloys with high mechanical properties. V: OLIVER, Martin (ur.). *Light Metals 2018*, (The minerals, metals & materials series (Print), ISSN 2367-1181). Cham: Springer. 2018, str. 373-380. 5. BALAŠKO, Tilen, VONČINA, Maja, MEDVED, Jože. Simultaneous thermal analysis of the high-temperature oxidation behaviour of three hot-work tool steels. *Journal of thermal analysis and calorimetry*. [Print ed.]. 2023, vol. 148, str. 1251-1264.     **Izr. prof. dr. Maja Vončina**   1. VONČINA, Maja, KRESNIK, Kristijan, VOLŠAK, Darja, PETRIČ, Mitja, MEDVED, Jože. Enthalpy balance of process path of the sheet production from EN AW 5182 aluminium alloy. *Journal of thermal analysis and calorimetry*. [Print ed.]. str. 1-9. 2. VONČINA, Maja, PAULIN, Irena, KRAČUN, Ana, NAGODE, Aleš. Modification of the cast structure of an EN AW 2011 alloy with homogenization = Modifikacija lite strukture zlitine EN AW 2011 s homogenizacijo. *Materiali in tehnologije*. [Tiskana izd.]. mar.-apr. 2021, letn. 55, št. 2, str. 327-333. 3. VONČINA, Maja, BALAŠKO, Tilen, MEDVED, Jože, NAGODE, Aleš. Interface reaction between molten Al99.7 aluminum alloy and various tool steels. *Materials*. 2021, vol. 14, iss. 24, str. 1-12. 4. VONČINA, Maja, NAGODE, Aleš, MEDVED, Jože, PAULIN, Irena, ŽUŽEK, Borut, BALAŠKO, Tilen. Homogenisation effciency assessed with microstructure analysis and hardness measurements in the EN AW 2011 aluminium alloy. *Metals*. 2021, vol. 11, iss. 8, str. 1-11. 5. VONČINA, Maja, MEDVED, Jože, KORES, Stanislav, XIE, Pan, SCHUMACHER, Peter, LI, Jiehua. Precipitation microstructure in Al-Si-Mg-Mn alloy with Zr additions. *Materials characterization*. [Print ed.]. 2019, vol. 155, str. 1-8. |

# Izbirni predmet 1 Učni načrt predmeta/Course syllabus

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| Predmet: | Izbirni predmet 1 |
| Course title: | Elective course 1 |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 1. letnik |  | obvezni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 1. letnik |  | obvezni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Rudarstvo in geotehnologija (smer) | 1. letnik |  | obvezni |

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| Univerzitetna koda predmeta/University course code: | 0111686 |
| Koda učne enote na članici/UL Member course code: | 850 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 0 | 0 | 0 | 0 | 75 | 75 | 5 |

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| Nosilec predmeta/Lecturer: |  |

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| Vrsta predmeta/Course type: |  |

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| Jeziki/Languages: | Predavanja/Lectures: |  |
|  | Vaje/Tutorial: |  |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
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| Vsebina: | Content (Syllabus outline): |
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| Temeljna literatura in viri/Readings: |
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| Cilji in kompetence: | Objectives and competences: |
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| Predvideni študijski rezultati: | Intended learning outcomes: |
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| Metode poučevanja in učenja: | Learning and teaching methods: |
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| Načini ocenjevanja: | Delež/Weight | Assessment: |
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| Reference nosilca/Lecturer's references: |
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# Izbirni predmet 2 Učni načrt predmeta/Course syllabus

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| Predmet: | Izbirni predmet 2 |
| Course title: | Elective course 2 |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 1. letnik |  | obvezni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 1. letnik |  | obvezni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Rudarstvo in geotehnologija (smer) | 1. letnik |  | obvezni |

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| Univerzitetna koda predmeta/University course code: | 0111690 |
| Koda učne enote na članici/UL Member course code: | 851 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 0 | 0 | 0 | 0 | 75 | 75 | 5 |

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| Nosilec predmeta/Lecturer: |  |

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| Vrsta predmeta/Course type: |  |

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| Jeziki/Languages: | Predavanja/Lectures: |  |
|  | Vaje/Tutorial: |  |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
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| Vsebina: | Content (Syllabus outline): |
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| Temeljna literatura in viri/Readings: |
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| Cilji in kompetence: | Objectives and competences: |
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| Predvideni študijski rezultati: | Intended learning outcomes: |
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| Metode poučevanja in učenja: | Learning and teaching methods: |
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| Načini ocenjevanja: | Delež/Weight | Assessment: |
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| Reference nosilca/Lecturer's references: |
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# Izbirni predmet 3 Učni načrt predmeta/Course syllabus

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| Predmet: | Izbirni predmet 3 |
| Course title: | Elective course 3 |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 1. letnik |  | obvezni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 1. letnik |  | obvezni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Rudarstvo in geotehnologija (smer) | 1. letnik |  | obvezni |

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| Univerzitetna koda predmeta/University course code: | 0111691 |
| Koda učne enote na članici/UL Member course code: | 852 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 0 | 0 | 0 | 0 | 75 | 75 | 5 |

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| Nosilec predmeta/Lecturer: |  |

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| Vrsta predmeta/Course type: |  |

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| Jeziki/Languages: | Predavanja/Lectures: |  |
|  | Vaje/Tutorial: |  |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
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| Vsebina: | Content (Syllabus outline): |
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| Temeljna literatura in viri/Readings: |
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| Cilji in kompetence: | Objectives and competences: |
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| Predvideni študijski rezultati: | Intended learning outcomes: |
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| Metode poučevanja in učenja: | Learning and teaching methods: |
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| Načini ocenjevanja: | Delež/Weight | Assessment: |
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| Reference nosilca/Lecturer's references: |
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# Izbor materialov za inženirske aplikacije Učni načrt predmeta/Course syllabus

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| Predmet: | Izbor materialov za inženirske aplikacije |
| Course title: | Materials Selection for Engineering Applications |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 1. letnik |  | izbirni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 1. letnik |  | izbirni |

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| Univerzitetna koda predmeta/University course code: | 0076031 |
| Koda učne enote na članici/UL Member course code: | 767 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 45 | 30 | 0 | 0 | 0 | 75 | 5 |

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| Nosilec predmeta/Lecturer: | Miran Gaberšček |

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| Vrsta predmeta/Course type: | Izbirni / Elective |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
| Vpis na doktorski študij materialov, znanje splošnih predmetov potrebnih za razumevanje materialov - iz 2. bolonjske stopnje kemijskega inženirstva ali materialov | General admission requirements to the PhD studies of Materials Science and Engineering, general knowledge as acquired through the 2nd cycle Bologna programme in Chemical Engineering or Materials Science studies |

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| Vsebina: | Content (Syllabus outline): |
| Po posvetu z mentorjem bodo študenti iz spodnjega seznama izbrali ustrezne predmete v skupnem obsegu 5 ECTS. Predmeti bodo izbrani tako, da bodo čim bilj prilagojeni raziskovalnim aktivnostim študenta. V primeru več predavateljev je za koordinacijo izvedbe tečaja odgovoren nosilec tečaja. (1) Struktura in lastnosti materialov; Poudarek bo na tem, kako struktura in mikrostruktura snovi določata njene lastnosti. Poglavje je razdeljeno na naslednja podpoglavja: (a) zgradba atoma in kemijska vez; (b) kristalna struktura in napake, (c) električne, mehanske in optične lastnosti kot posledica strukture in lastnosti materialov, s poudarkom na materialih, ki jih pogosto srečamo v praksi. (2) Obdelava materialov: Poudarek bo na razumevanju razvoja mikrostrukture kot posledice različnih tehnik priprave in sinteze materialov. Poglavje bo razdeljeno na podpoglavja: (i) ravnotežni fazni diagrami; difuzija v trdnih snoveh; (ii) taljenje, strjevanje in ulivanje; plastična deformacija in žarjenje, toplotna obdelava. Poseben poudarek bo na: jeklih (ogljikovih in zlitinah), aluminiju, keramiki, steklu, polimernih kompozitih, keramičnih kompozitih, kompozitih s kovinsko matrico, naprednih keramičnih materialih (LTTC, FGM...). Specifični del: Poudarek bo na lastnostih materialov, ki so pomembne za načrtovanje komponent in sistemov. (iii) Upoštevana bo splošna metodologija izbire materialov ter ustrezna merila in orodja. Poseben poudarek bo na razgradnji (koroziji) materialov. Podrobneje bodo obravnavani naslednji postopki: sinteza materialov, določanje sestave, strukture, morfologije in drugih splošnih lastnosti materialov, priprava praškov, oblikovanje materialov, sušenje, sintranje, toplotne, kemične in mehanske obdelave. Vsi procesi bodo obravnavani na mikro in nano skalah. (iv) V zadnjem podpoglavju se bomo osredotočili na karakterizacijo materialov in oceno njihove funkcionalnosti. Študenti bodo pripravili seminar o izbranih naprednih fizikalnih ali kemijskih metodah sinteze materialov. | Upon consultations with the mentor, students will choose appropriate courses from the list below in a total amount of 5 ECTS. The courses will be selected in accordance with the student's particular research inerests. In case of multiple lecturers, it is the responsibility of the course leader to coordinate the implementation of the course. (1) Structure and properties of materials; The emphasis will be on how the structure and microstructure of matter determine its properties. The chapter is divided into the following subchapters: (a) atomic structure and chemical bonding; (b) crystal structure and defects, (c) electrical, mechanical and optical properties as a consequence of the structure and properties of materials that are essential for the application. (2) Processing of materials: The emphasis will be on the development of the microstructure as a consequence of various materials preparation and synthesis techniques. The chapter will be divided into subchapters: (i) equilibrium phase diagrams; diffusion in solids; (ii) melting, solidification and casting; plastic deformation and annealing, heat treatment. Special emphasis will be on: steels (carbon based and alloys), aluminium, ceramics, glasses, polymeric composites, ceramic composites, composites with metallic matrix, advanced ceramic materials (LTTC, FGM...). Specific part: The focus will be on the materials properties that are important for designing components and systems. (iii) General methodology for construction building, methodology of materials selections, and the corresponding criteria and tools will be considered. A special emphasis will be on degradation (corrosion) of materials. The following processes will be considered in detail: materials synthesis, determination of composition, structure, morphology and other general materials properties, preparation of powders, materials design, drying, sintering, thermal, chemical and mechanical treatments. All the processes will be considered on micro and nano scales.(iv) Finally, materials characterization and evaluation of functionality will be considered. Students will prepare a seminar on selected advanced physical or chemical methods of materials synthesis. |

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| Temeljna literatura in viri/Readings: |
| 1. The Principles of Materials Selection for Engineering Design, Pat L. Mangonon, Prentice Hall, New Jersey, 1999 DODATNI ŠTUDISJKI VIRI 2. Microstructural Characterization of Materials, D. Brandon, W.D. Kaplan, Wiley, 2008 3. Foundations of Materials Science and Engineering, Fourth Ed., W.F. Smith, J. Hashemi, McGraw Hill, 2006 4. Corrosion Engineering, Principles and Practice, P.R. Roberge, McGraw Hill, 2008 5. S.Pejovnik, M.Gaberšček, Uvod v vedo o materialih za inženirje |

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| Cilji in kompetence: | Objectives and competences: |
| Predmet je zasnovan modularno in bo sestavljen iz osnovnega dela, ki bo skupen za vse študente ter specifičnega dela, ki bo prilagojen vsakemu študentu. Da bi inženir lahko odločil, kateri material je najprimernejši za neko aplikacijo, mora poznati tiste lastnosti materiala, ki so odločilne za izbrano komponento ali celoten sklop. To so predvsem fizikalne, kemijske in mehanske lastnosti gradiv. V uvodnem delu bodo obravnavani osnovni principi, ki razložijo kako lastnosti »nastanejo«, kako se spreminjajo z makro- in mikrostrukturo, sestavo, načini procesiranja in končne izdelave. V specifičnem delu bo predavatelj z vsakim študentom izbral temo, ki jo bo študent seminarsko obdelal. Vsebina bo prilagojena doktorskemu delu tako, da bodo izbrane predvsem tiste vsebine, ki jih študent v dosedanjem študiju še ni obvladal. Seminar bo obsegal teoretske podlage, potrebne za razumevanje problema, literaturni pregled in praktične aplikacije poznane iz literature. | The nature of course is modular and is composed of a general part common to all students and a specific part suited to each individual student. In order for an engineer to decide which material is the most suited for certain application, one has to know the properties of the material that are decisive for the selected component or the whole assembly. These properties are above all the physical, chemical and mechanical ones. In the introductory part, the basic principles will be considered which explain “how” the properties come by, how they change with macro- and microstructure, composition, processing route and final assembly. In the specific part of the course the theme for the student's seminar will be chosen by lecturer together with each student. The theme of the seminar will be suited to the doctoral thesis so that only chapters yet noncomprehended by the student will be treated. The seminar will consist of theoretical background needed for the understanding of the problem, literature research and practical application of the open literature. |

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| Predvideni študijski rezultati: | Intended learning outcomes: |
| Znanje in razumevanje: | Knowledge and understanding: |

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| Metode poučevanja in učenja: | Learning and teaching methods: |
| Metode so prilagojene študentu oziroma skupini: predavanja, študij ustrezne strokovne literature, laboratorijsko delo na izbranem področju, seminar in razprave v ožji skupini. | Teaching methods will be adjusted to students or a group of students and will generally comprise of: lectures, literature study, laboratory work, seminars and discussions within small groups. |

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| Načini ocenjevanja: | Delež/Weight | Assessment: |
| Način preverjanja znanja se dogovori individualno z vsakim študentom doktorskega študija in se lahko izvaja v obliki ustnega in/ali pisnega izpita, seminarja ali izdelave projekta oziroma pisanja znanstvenega članka. | 0,00 % | Type of examination will be determined individually. Any of the following modes will be applicable: oral and/or written examination, seminar, project work, engagement in a scientific report preparation. |

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| Reference nosilca/Lecturer's references: |
| (1) Gaberšček, Miran. Understanding Li-based battery materials via electrochemical impedance spectroscopy. *Nature communications*. 2021, 12, pp. 1-4.  (2) S. Drvarič Talian, J. Moškon, R. Dominko, and M. Gaberšček, Reactivity and Diffusivity of Li Polysulfides: A Fundamental Study Using Impedance Spectroscopy, *ACS Appl. Mater. Interfaces*, 2017, 9, pp. 29760–29770.  (3) Moriau, Leonard, Bele, Marjan, Vižintin, Alen, Ruiz-Zepeda, Francisco, Petek, Urša, Jovanovič, Primož, Šala, Martin, Gaberšček, Miran, Hodnik, Nejc. Synthesis and advanced electrochemical characterization of multifunctional electrocatalytic composite for unitized regenerative fuel cell. *ACS catalysis,* 2019, 9, pp. 11468-11483W.  (4) Drvarič Talian, Sara, Kapun, Gregor, Moškon, Jože, Vižintin, Alen, Randon-Vitanova, Anna, Dominko, Robert, Gaberšček, Miran. Which process limits the operation of a Li-S system?. *Chemistry of materials,* 2019, 31, pp. 9012-9023.  (5) Dreyer, J. Jamnik, C. Guhlke, R. Huth, J. Moskon, M. Gaberscek, The thermodynamic origin of hysteresis in insertion batteries. *Nature materials*, 2010, vol. 9, pp. 448-453. |

# Izdelava in karakterizacija materialov Učni načrt predmeta/Course syllabus

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| Predmet: | Izdelava in karakterizacija materialov |
| Course title: | Production and Characterisation of Materials |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 1. letnik |  | izbirni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 1. letnik |  | izbirni |

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| Univerzitetna koda predmeta/University course code: | 0076032 |
| Koda učne enote na članici/UL Member course code: | 768 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 30 | 30 | 15 | 0 | 0 | 75 | 5 |

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| Nosilec predmeta/Lecturer: | Milan Bizjak |

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| Vrsta predmeta/Course type: | Izbirni / Elective |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
| Veljajo splošni pogoji za doktorski študij. Pogoj za vključitev v delo oziroma za opravljanje študijskih obveznosti je vpis v 2. letnik študija. | General admission requirements for enrolment to the third cycle studies. Lecture attendance and participation in research work is a prerequisite for enrolment in the in 2nd year of study. |

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| Vsebina: | Content (Syllabus outline): |
| Načrtovanje materialov s poudarkom na mehanskih lastnostih. Realizacija mehanizmov utrjevanja. Legiranje, hitro strjevanje, fazne transformacije, toplotne in termomehanske obdelave. Modeliranje procesov toplotnih in termomehanskih obdelav. Računalniško vrednotenje in napovedovanje lastnosti materialov. Difuzijsko kontrolirani procesi. Metalurgija prahov. Kompoziti. Vlakna Inženirska keramika. Fizikalna keramika. Biomateriali. Analiza, karakterizacija in preizkušanje materialov. | Design and materials selection with emphasis on mechanical properties. Mechanisms of material hardening. Alloying, rapid solidification, phase transformations, thermal and thermo - mechanical treatments. Heat and thermo - mechanical treatments modelling. Computer evaluation and material properties prediction. Diffusion control processes. Powder metallurgy. Composites. Fibres. Technical ceramics. Physical ceramics. Biomaterials. Analysis, characterization and material testing. |

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| Temeljna literatura in viri/Readings: |
| WALTER J.L., JACKSON M.R., SIMS C.T. Alloying. Mateials Park Ohio: ASM International, 1988. TOTTEN, G.E., XIE L., FUNATANI K.. Handbook of Mechanical Alloy Design. New York: Marcel Dekker, 2004. ASHBY, M., SHERCLIFF, H., CEBON, D. Materials – Engineering, Science, Processing and Design. Amsterdam: Elsevier, 2007. YOUNG J.F., SHANE R.S.. Materials and Processes. New York: Marcel Dekker, 1985. GEGNER J.. Komplexe Diffusinprozesse in Metallen. Renningen: Expert Verlag, 2006. HONEYCOMBE R.W.K., BHADESHIA H.K.D.H. Steels. Microstructure and Properties. London: Edward Arnold, 2006. TOTTEN, G.E., HOWES, M.A.H., TATSUO, I. Handbook of Residual Stress and Deformation of Steel. Mateials Park Ohio: ASM International, 2002. THIMMLER, F., OBERACHER, R. Introduction to Powder Metallurgy. Cambridge: Cambridge University Press, 1993. CHAWLA, K.K. Composite Materials: Science and Engineering. Berlin: Springer Verlag, 1987. MISCH, C.E. Contemporary Implant Dentistry. St.Louis: Mosby, Elsevier, 2008. TOTTEN, G.E., HOWES, M.A.H. Steel Heat Treatment Handbook. New York: Marcel Dekker, 1997. |

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| Cilji in kompetence: | Objectives and competences: |
| Študent nadgradi pridobljena teoretična, metodološka in eksperimentalna znanja na področjih načrtovanja, sinteze, karakterizacije in selekcije materialov. Razvija inovativnost, samostojnost in delo v skupini. | Students will deepen the acquired theoretical, methodological and experimental knowledge in the field of design, synthesis, characterization, and materials selection. Student will acquire skills for performing individual and team research work. |

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| Predvideni študijski rezultati: | Intended learning outcomes: |
| Znanje in razumevanje: Znanje iz fizikalne metalurgije, teorije termodinamike in eksperimentalnih tehnik za analizo in načrtovanje materialov. | Knowledge and understanding: Knowledge of physical metallurgy, theory of thermodynamics and experimental techniques for the analysis and material design. |

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| Metode poučevanja in učenja: | Learning and teaching methods: |
| Predavanja. Računske vaje. Simulacije. Laboratorijsko delo. Samostojno obravnavanje problemov in raziskovalno delo. | Lectures, computer calculation and numerical simulation exercises. Laboratory work. Team and independent problem-solving. Scientific research work. |

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| Načini ocenjevanja: | Delež/Weight | Assessment: |
| Ustni /pisni izpiti – teorija in problemi, Izdelava, predstavitev in uspešen zagovor raziskovalnih nalog. | 0,00 % | Oral / written exams - theory and problems: Solving open tasks (problems), elaboration, presentation and successful defence of a research project task. |

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| Reference nosilca/Lecturer's references: |
| KARPE, Blaž, KOSEC, Borut, NAGODE, Aleš, **BIZJAK, Milan**. The influence of Si and V on the kinetics of phase transformation and microstructure of rapidly solidified Al-Fe-Zr alloys. *Journal of mining and metallurgy. Section B, Metallurgy*, ISSN 1450-5339, 2013, vol. 49 B, no. 1, str. 83-89  MOČNIK, Petra, KOSEC, Tadeja, KOVAČ, Janez, **BIZJAK, Milan**. The effect of pH, fluoride and tribocorrosion on the surface properties of dental archwires. *Materials science & engineering. C, Materials for biological applications*, ISSN 0928-4931. [Print ed.], 2017, vol. 78, str. 682-689,  NOVAK, Gašper, KOKOŠAR, Janko, BRICELJ, Miran, **BIZJAK, Milan**, STEINER PETROVIČ, Darja, NAGODE, Aleš. Improved model based on the modified Steinmetz equation for predicting the magnetic losses in non-oriented electrical steels that is valid for elevated temperatures and frequencies. *IEEE transactions on magnetics*, ISSN 0018-9464, Oct. 2017, vol. 53, iss. 10, str. [1-5],  IVANIĆ, Ivana, KOŽUH, Stjepan, KOSEL, Franc, KOSEC, Borut, ANŽEL, Ivan, **BIZJAK, Milan,** GOJIĆ, Mirko. The influence of heat treatment on fracture surface morphology of the CuAlNi shape memory alloy. *Engineering failure analysis*, ISSN 1350-6307. [Print ed.], 2017, vol. 77, str. 85-92  HOLJEVAC-GRGURIĆ, Tamara, MANASIJEVIĆ, Dragan, KOŽUH, Stjepan, IVANIĆ, Ivana, BALANOVIĆ, Ljubiša, ANŽEL, Ivan, KOSEC, Borut, **BIZJAK, Milan**, KNEŽEVIĆ, Monika, GOJIĆ, Mirko. Phase transformation and microstructure study of the as-cast Cu-rich Cu-Al-Mn ternary alloys. *Journal of mining and metallurgy. Section B, Metallurgy*, ISSN 1450-5339, 2017, vol. 53 B, no. 3, str. 413-422  NAGODE, Aleš, JERINA, Kaja, JERMAN, Ivan, VELLA, Daniel, **BIZJAK, Milan**, KOSEC, Borut, KARPE, Blaž, ZORC, Borut. The effect of sol-gel boehmite coatings on the corrosion and decarburization of C45 steel. *Journal of sol-gel science and technology*, ISSN 0928-0707, 2018, vol. , iss. , str. 1-12 |

# Javna predstavitev izhodišč za doktorsko disertacijo Učni načrt predmeta/Course syllabus

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| Predmet: | Javna predstavitev izhodišč za doktorsko disertacijo |
| Course title: | Public Presentation of Research Hypothesis |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 1. letnik |  | obvezni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 1. letnik |  | obvezni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Rudarstvo in geotehnologija (smer) | 1. letnik |  | obvezni |

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| Univerzitetna koda predmeta/University course code: | 0076014 |
| Koda učne enote na članici/UL Member course code: | 803 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 0 | 0 | 0 | 0 | 0 | 150 | 5 |

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| Nosilec predmeta/Lecturer: |  |

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| Vrsta predmeta/Course type: | Obvezni / Compulsory |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
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| Vsebina: | Content (Syllabus outline): |
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| Temeljna literatura in viri/Readings: |
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| Cilji in kompetence: | Objectives and competences: |
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| Predvideni študijski rezultati: | Intended learning outcomes: |
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| Metode poučevanja in učenja: | Learning and teaching methods: |
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| Načini ocenjevanja: | Delež/Weight | Assessment: |
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| Reference nosilca/Lecturer's references: |
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# Javna predstavitev rezultatov raziskovalnega dela, javni zagovor doktorske disertacije ter objava oz. sprejetje v objavo znanstvenega članka Učni načrt predmeta/Course syllabus

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| Predmet: | Javna predstavitev rezultatov raziskovalnega dela, javni zagovor doktorske disertacije ter objava oz. sprejetje v objavo znanstvenega članka |
| Course title: | Successful Defence of the PhD Thesis |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 4. letnik |  | obvezni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 4. letnik |  | obvezni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Rudarstvo in geotehnologija (smer) | 4. letnik |  | obvezni |

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| Univerzitetna koda predmeta/University course code: | 0135820 |
| Koda učne enote na članici/UL Member course code: | 805 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 0 | 0 | 0 | 0 | 0 | 150 | 5 |

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| Nosilec predmeta/Lecturer: |  |

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| Vrsta predmeta/Course type: | Obvezni / Compulsory |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
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| Vsebina: | Content (Syllabus outline): |
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| Temeljna literatura in viri/Readings: |
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| Cilji in kompetence: | Objectives and competences: |
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| Predvideni študijski rezultati: | Intended learning outcomes: |
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| Metode poučevanja in učenja: | Learning and teaching methods: |
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| Načini ocenjevanja: | Delež/Weight | Assessment: |
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| Reference nosilca/Lecturer's references: |
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# Kemija trdnega stanja Učni načrt predmeta/Course syllabus

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| Predmet: | Kemija trdnega stanja |
| Course title: | Solid State Chemistry |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 1. letnik |  | izbirni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 1. letnik |  | izbirni |

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| Univerzitetna koda predmeta/University course code: | 0076033 |
| Koda učne enote na članici/UL Member course code: | 759 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 15 | 15 | 0 | 0 | 45 | 75 | 5 |

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| Nosilec predmeta/Lecturer: | Anton Meden |

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| Vrsta predmeta/Course type: | Izbirni / Elective |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
| Vpis v letnik. | General admission requirements. |

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| Vsebina: | Content (Syllabus outline): |
| 1. Amorfna in kristalinična zgradba trdne snovi. Periodičnost in simetrija v kristalih. 2. Teorija difrakcijskih metod (rentgenski žarki, nevtroni, pospešeni elektroni, sipanje na elektronih in atomih, interferenca, kristalne ravnine, indeksi, Braggova enačba, Braggov pogoj, nastanek uklonske slike na monokristalu in polikristaliničnem materialu, recipročna mreža, interpretacija uklonske slike). 3. Uporaba difrakcije (osnovne uporabe praškovne difrakcije: kvalitativna in kvantitativna fazna analiza, določitev parametrov osnovne celice, mikrostrukture; osnove določanja strukture - monokristalni ali praškovni podatki). 4. Napake v kristalih: atomske in elektronske napake in povezava med njimi 5. Kompletno ravnotežje napak v elementnih kristalih, Brouwerjeve aproksimacije in ravnotežja v nestehiometričnih binarnih oksidih. 6. Obravnava osnove mehanizmov difuzije in fenomenološka obravnava transportnih procesov. Mehanska gibljivost. Atomistična teorija difuzije. 7. Kriteriji nastanka zelo tankih in tankih plasti. Zakonitosti parabolične oksidacije nekaterih tankih oksidnih plasti. | 1. Amorphous and crystalline structure of solids. Periodicity and symmetry of crystals. 2. Theory of diffraction methods (X-rays, neutrons, accelerated electrons, scattering on electrons and atoms, interference, crystal planes, indices, Bragg equation, Bragg condition, diffraction pattern of a single crystal and a polycrystalline material, reciprocal net, interpretation of the diffraction pattern). 3. Application of diffraction (basic applications of powder diffraction: qualitative and quantitative phase analysis, determination of the unit cell parameters, microstructure, basics of structure determination - by single crystal or powder diffraction data). 4. The point-defects in crystals: atomic and electronic defects and connections between them. 5. The complete defect equilibrium in elemental crystals, Brouwer's approximations and the defect-equilibrium in binary oxides. 6. The basic principles of diffusion and the phenomenological treatment of transport-processes. Atomistic theory of diffusion. 7. Criteria for the formation of thin and very thin solid layers. The parabolic oxidation of some thin oxide layers. |

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| Temeljna literatura in viri/Readings: |
| 1. R. Tilley, Crystals and crystal structures, John Wiley and Sons, Chicester, England 2007, strani 1-180 od 255. 2. V. K. Pecharsky, P. Y. Zavalij: Fundamentals of powder diffraction and structural characterization of materials, New York: Springer, 2005. 3. W. Clegg, Crystal structure analysis: principles and practice, International Union of Crystallography, Oxford, New York : Oxford University Press, 2001. 4. A. R. West., Solid state chemistry and its applications, New York: John Wiley and Sons, 1989. 5. C. N. R. Rao, J. Gopalakrishnan, New directions in solid state chemistry, Cambridge; Cambridge University Press, 1997. |

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| Cilji in kompetence: | Objectives and competences: |
| Pridobitev specialni ožjih znanj, ki v kombinacijami z drugimi znanji omogočajo samostojno raziskovanje na določenem izbranem področju. | Acquisition of new knowledge which – in combination with the knowledge from other subjects – is basic for independent research in a selected area. |

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| Predvideni študijski rezultati: | Intended learning outcomes: |
| Znanje in razumevanje. | Knowledge and understanding. |

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| Metode poučevanja in učenja: | Learning and teaching methods: |
| Predavanja, seminarji, domače naloge in konzultacije, reševanje praktičnih problemov, po možnosti na vzorcih iz raziskovalnega dela študenta. | Lectures, seminars home work, and consultations, solving practical problems, if possible with samples, taken from the student's research work. |

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| Načini ocenjevanja: | Delež/Weight | Assessment: |
| Seminarska naloga | 50,00 % | Seminar work |
| Ustni izpit | 50,00 % | Oral exam |

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| Reference nosilca/Lecturer's references: |
| 1. M. Vidmar, A. Golobič, A. Meden, D. Suvorov, S. D. Škapin. Sub-solidus phase relations and a structure determination of new phases in the CaO-La2O3-TiO2 system. *Journal of the European ceramic society*, 35, 2801-2814, 2015. 2. Y. Sadikin, K. Stare, P. Schouwink, M. B. Ley, T. Jensen, A. Meden, R. Černy. Alkali metal - yttrium borohydrides : the link between coordination of small and large rare-earth. *Journal of solid state chemistry*, 225, 231-239, 2015. 3. F. Zupanič, B. Markoli, I. Naglič, T. Weingaertner, A. Meden, T. Bončina. Phases in the Al-corner of the Al-Mn-Be system. *Microscopy and microanalysis*, 19(5), 1308-1316, 2013. |

# Keramični materiali Učni načrt predmeta/Course syllabus

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| Predmet: | Keramični materiali |
| Course title: | Ceramic Materials |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 1. letnik |  | izbirni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 1. letnik |  | izbirni |

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| Univerzitetna koda predmeta/University course code: | 0076034 |
| Koda učne enote na članici/UL Member course code: | 785 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 15 | 60 | 0 | 0 | 0 | 75 | 5 |

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| Nosilec predmeta/Lecturer: | Boštjan Genorio |

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| Vrsta predmeta/Course type: | Izbirni / Elective |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
| Znanje osnovnih predmetov druge bolonjske stopnje iz področja materialov | Basic courses on materials science from the second cycle of Bologna study programme |

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| Vsebina: | Content (Syllabus outline): |
| Predmet je razdeljen na naslednja poglavja : 1. Uvod a. strukturne lastnosti (vezi, kristalne strukture, kompleksne strukture, defekti, difuzija, itd) b. mikrostrukturne lastnosti (medpovršine, fazne meje, velikost zrn in por, itd)  2. Lastnosti keramike (mehanske, električne, optične) a. Mehanske lastnosti: plastičnost, dislokacijsko drsenje, zlom, difuzijsko kontroliran zlom, drsenje na mejah med zrni, viskoznostni tok, superplastičnost, itd. b. Električne in magnetne lastnosti: prevodnost, gibljivost elektronov, vpliv temperature, defektna struktura in dopiranje, itd 3. Procesiranje keramike a. surovine, b. osnovne metode oblikovanja keramičnih prahov c. termična obdelava (sintranje) d. tehnološki postopki | Course is divided into the following chapters: 1. Introduction a. structural properties (bonds, crystal structures, complex structures, defects, diffusion, etc.) b. microstructure properties (interfaces, phase boundaries, grain size, pore size, etc.) 2. Properties of ceramic (mechanical, electrical, optical) a. Mechanic properties: plasticity, dislocation sliding, fracture, diffusion controlled fracture, sliding on the grain boundaries, viscous flow, super plasticity, etc. b. Electric and magnetic properties: conductivity, electron mobility, temperature influence, defect structure and doping, etc. 3. Ceramic processing a. raw materials b. basic methods of forming c. thermal treatment – sintering d. technological processes |

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| Temeljna literatura in viri/Readings: |
| William D. Callister Jr., David G. Rethwisch; Materials Science and Engineering: An Introduction, 9th Edition, 2014, USA  C. B. Carter, M. G. Norton, Ceramic Materials – Science and Engineering, Springer Science + Business Media, LLC, 2007  Kasap, Principles of Electronic Materials and Devices, McGraw-Hill, 2002, NY, USA   * T. A. Ring, Fundamentals of Ceramic Powder Processing and Synthesis, Academic Press, 1996, San Diego, USA |

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| Cilji in kompetence: | Objectives and competences: |
| Cilji: V okviru predmeta se študentje spoznajo s strukturo in lastnostmi keramičnih materialov, z njihovimi fizikalnimi in kemijskimi lastnostmi ter s tehnološkimi procesi njihove izdelave. Zaželeni cilj predmeta je poznavanje keramike na nivoju, ki omogoča povezavo strukturnih lastnosti in razvoja mikrostrukture med procesom sintranja z rezultirajočimi lastnostmi keramike (mehanskimi, električnimi, optičnimi, itd). Specifične kompetence: V okviru predmeta študentje spoznajo osnovne principe o strukturi (kemijske vezi, kristalne strukture, defekti in napake, visokotemperaturni fazni diagrami), karakterizacijskih metodah (rentgenska analiza, diferenčna termična analiza, optična in elektronska mikroskopija) in lastnostih keramike. Prav tako spozna tehnološke procese za izdelavo keramičnih materialov. | Goals: course introduces students with the structures and properties of ceramic materials with emphasis on physical and chemical properties and the processes of their manufacture. The final goal of the course is to understand ceramics on the level which will enable logic linking of structural properties and microstructure development during sintering with resulting properties of fired ceramics (mechanical, electrical, optical, etc.) Specific competences: Within the course students will learn basic principles about structure (chemical bonds, crystal structures, defects and irregularities, high temperature phase diagrams), characterization methods (x-ray, DTA-TG, optical and electronic microscopy) and properties of ceramic. Basic technology processes for the ceramic manufacturing will be described as well. |

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| Predvideni študijski rezultati: | Intended learning outcomes: |
| Znanje in razumevanje. | Knowledge and understanding. |

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| Metode poučevanja in učenja: | Learning and teaching methods: |
| Predavanja in seminarji. | Lectures and seminars. |

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| Načini ocenjevanja: | Delež/Weight | Assessment: |
| Seminarji in izpit | 100,00 % | Seminar and examination |

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| Reference nosilca/Lecturer's references: |
| 1. Genorio, B., Pirnat, K., Cerc-Korosec, R., Dominko, R. & Gaberscek, M. Electroactive organic molecules immobilized onto solid nanoparticles as a cathode material for lithium-ion batteries. *Angew. Chemie - Int. Ed.* **49,** 7222–7224 (2010). 2. Genorio, B. *et al.* Synthesis of dispersible ferromagnetic graphene nanoribbon stacks with enhanced electrical percolation properties in a magnetic field. *ACS Nano* **6,** 10396–10404 (2012). 3. Staszak-Jirkovský, J. *et al.* Design of active and stable Co-Mo-Sx chalcogels as pH-universal catalysts for the hydrogen evolution reaction. *Nat. Mater.* **15,** 197–203 (2016). 4. Bobnar, J. *et al.* Fluorinated reduced graphene oxide as a protective layer on the metallic lithium for application in the high energy batteries. *Sci. Rep.* **8,** 5819 (2018). 5. Šest, E., Dražič, G., Genorio, B. & Jerman, I. Graphene nanoplatelets as an anticorrosion additive for solar absorber coatings. *Sol. Energy Mater. Sol. Cells* **176,** (2018). |

# Konstitucija večkomponentnih zlitinskih sistemov Učni načrt predmeta/Course syllabus

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| Predmet: | Konstitucija večkomponentnih zlitinskih sistemov |
| Course title: | Constitution of Multi - component Metallic Systems |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 1. letnik |  | izbirni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 1. letnik |  | izbirni |

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| Univerzitetna koda predmeta/University course code: | 0076035 |
| Koda učne enote na članici/UL Member course code: | 761 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 15 | 30 | 0 | 0 | 30 | 75 | 5 |

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| Nosilec predmeta/Lecturer: | Boštjan Markoli |

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| Vrsta predmeta/Course type: | Izbirni / Elective |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
| Veljajo splošni pogoji za doktorski študij. Pogoj za vključitev v delo oziroma za opravljanje študijskih obveznosti je vpis v II. letnik podiplomskega študija. | Subject to general conditions for doctoral studies. The condition for inclusion in the work or to undertake work commitments is an entry in the II. year of postgraduate study. |

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| Vsebina: | Content (Syllabus outline): |
| Fizikalno-metalurške osnove zgradbe binarnih in ternarnih zlitinskih sistemov. Fazna ravnotežja (reakcije ni premene), ki nastopajo v teh sistemih. Značilnosti potekov reakcij evtektičnega, peritektičnega, monotektičnega, sintektičnega in metatektičnega tipa. Obravnava poteka premen v trdnem stanju (evtektoidna, peritektoidna, metatektoidna itd. premena) s procesi razmešanja in urejevanja. Prehod na obravnavo značilnosti zgradbe štiri- in večkomponentnih sistemov. Napovedovanje konstitucije večkomponentnih zlitinskih sistemov z uorabo različnih pristopov. Modeliranje zgradbe večkomponentnih sistemov in napovedovanje faznih ravnotežij. | Physico-metallurgical principles of binary and ternary alloy system constitution. Phase equilibria (reactions and transformations) which appear in these systems. Properties of eutectic, peritectic, monotectic, syntectic and metatectic type reactions. Consideration of transformations in solid state (eutectoid, pertiectoid, meonotectoid etc.) along with process of dissolution and ordering. Consideration of properties and constitution of four-component and multi-component systems. Prediction on the constitution of multicomponent alloy systems by the use of different approaches. Modelling of the constitution of multicomponent systems and prediction on the phase equilibria. |

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| Temeljna literatura in viri/Readings: |
| Hansen, Friedhelm Beiner, Heterogene Gleichgewichte Walter de Gruyter Verlag,, Berlin 1974 Bruno Predel, Heterogene Gleichgewichte Steinkopff -Verlag, Darmstadt, 1982 ISBN 3-7985-0595-0 Bruno Predel, Michael Hoch, Monte Pool Phase Diagrams and Heterogeneous Equilibria Springer Verlag, 2004, ISBN: 3-540-14011-5, 75 € Mats Hillert, Phase Equilibria, Phase Diagrams and Phase Transformations, Cambridge University Press,1998, ISBN-10: 0521565847, ca. 50 € G. Masing, Ternary Phase Equilibria, Dover Publications, New York, 1944 A.Prince, Alloy Phase Equilibria, Elsevier, Amsterdam 1966 H. Schumann, Metallographie, Deutscher Verlag für Grundstoffindustrie, Leipzig, 1991 G. Gottstein, Physikalische Grundlagen der Materialkund,e Springer Verlag 1998 D.R.F. West, Ternary Equilibrium Diagrams, 2nd Edition, Chapman and Hall, London 1982 |

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| Cilji in kompetence: | Objectives and competences: |
| Cilj izbirnega predmeta Konstitucija večkomponentnih zlitinskih sistemov je podati poglobljeno znanje o zgradbi in metodah konstruiranja ter modeliranja večkomponentnih zlitinskih sistemov na fizikalno-metalurških osnovah. Pridobljena znanja predstavljajo podlago za razumevanje in reševanje vrste procesnih problemov povezanih s sintezo kovinskih materialov, strjevanjem le-teh pri postopkih izdelave in premenami, ki potekajo v trdnem stanju kovinskih materialov. | The aim of the course the Constitution of multicomponent alloy systems is to provide detailed knowledge about the structure and methods of design and modeling of multicomponent alloy systems based physico-metallurgcal fundamentals. Acquired knowledge as the basis for understanding and solving type of process problems related to the synthesis of metallic materials, solidification during manufacturing and transformations taking place in the solid state of metallic materials. |

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| Predvideni študijski rezultati: | Intended learning outcomes: |
| Znanje in razumevanje: Kandidati pridobijo posebna znanja s področja fizikalne metalurgije povezana konstitucijo večkomponentnih zlitin preko sistematične obravnave značilnosti zgradbe in zakonitosti ternarnih in kvaternih zlitinskih sistemov. To je nujno pri poglobljenem študiju reakcij in procesov v staljenem in trdnem stanju za celo vrsto tehničnih kovinskih materialov. Kandidati prav tako razvijejo razumevanje vpliva različnih fizikalno-metalurških dejavnikov na razvoj konstitucije večkomponentnih kovinskih materialov in se preko uporabe naprednih pristopov, modelov in simulacij usposobijo za nadgradnjo obstoječih in razvoj novih kompleksnih kovinskih materialov. | Knowledge and understanding: Candidates gain specific knowledge from the field of physical metallurgy related to the constitution of multicomponent alloys through systematic treatment of characteristics of the constitution and the rules of ternary and quaternary alloying systems. This is necessary for the in-depth study of reactions and processes in the molten and solid state for a range of technical metallic materials . Candidates also develop an understanding of the impact of various physico-metallurgical factors on the development of a constitution of multicomponent metallic materials and through the use of advanced approaches, models and simulations, the ability to upgrade existing and develop new complex metallic materials. |

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| Metode poučevanja in učenja: | Learning and teaching methods: |
| Predavanja, konzultacije, seminarji, laboratorijske vaje. | Lecturing, consultations, seminars, laboratory work. |

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| Načini ocenjevanja: | Delež/Weight | Assessment: |
| Seminar | 50,00 % | Seminars |
| Ustni zagovor | 50,00 % | Oral presentation of seminars |

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| Reference nosilca/Lecturer's references: |
| 1. LESKOVAR, Blaž, ŠTURM, Sašo, SAMARDŽIJA, Zoran, AMBROŽIČ, Bojan, MARKOLI, Boštjan, NAGLIČ, Iztok. Epitaxial growth of a metastable icosahedral quasicrystal on a stable icosahedral quasicrystal substrate. *Scripta materialia*, ISSN 1359-6462, 2018, vol. 150, str. 92-95 2. ZUPANIČ, Franc, MARKOLI, Boštjan, NAGLIČ, Iztok, WEINGÄRTNER, Tobias, MEDEN, Anton, BONČINA, Tonica. Phases in the Al-corner of the Al-Mn-Be system. *Microscopy and microanalysis*, ISSN 1431-9276. [Print ed.], Oct. 2013, vol. 19, iss. 5, str. 1308-1316 3. MARKOLI, Boštjan. Fizikalna metalurgija I: ternarni in kvaterni sistemi. 2. izd. Ljubljana: Naravoslovnotehniška fakulteta, Oddelek za materiale in metalurgijo, 2009. ISBN 978-961-6047-67-8. 4. MARKOLI, Boštjan, BONČINA, Tonica, ZUPANIČ, Franc. How can we distinguish quasicrystals from other phases in Al-based cast alloys containing Mn, Mg, Si, Be, Cu, Ce, Fe and Ti?. *Recent patents on materials science*, ISSN 1874-4648, 2015, vol. 108, no. 2, str. 109-118. |

# M5 - Modeliranje procesov Učni načrt predmeta/Course syllabus

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| Predmet: | M5 - Modeliranje procesov |
| Course title: | M5-Modelling of Processes |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 1. letnik |  | izbirni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 1. letnik |  | izbirni |

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| Univerzitetna koda predmeta/University course code: | 0076036 |
| Koda učne enote na članici/UL Member course code: | 765 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 45 | 30 | 0 | 0 | 0 | 75 | 5 |

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| Nosilec predmeta/Lecturer: | Goran Kugler, Tomaž Rodič |

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| Vrsta predmeta/Course type: | Izbirni / Elective |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
| Opravljen magistrski študij ter poznavanje mehanike, fizikalne metalurgije in osnov fizike trdne snovi. | Completed master’s program, prior knowledge of mechanics, physical metallurgy and basic knowledge of solid state physics. |

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| Vsebina: | Content (Syllabus outline): |
| • Konstitutivno modeliranje materialov na različnih časovnih in dimenzijskih skalah: MAKROmehanski konstitutivni modeli, MIKROmehanski modeli in reprezentativni volumenski elementi za kompozite in porozne materiale, modeli za analize pojavov na NANO ravneh. • Metode za prostorsko in časovno diskretizacijo nelinearnih problemov: Izbrana poglavja za napredne M5 analize po Metodi Končnih Elementov (MKE) in Metodi Diskretnih Elementov (MDE). • Izbrana poglavja iz modeliranja na nivoju atomov in uporaba atomističnih metod v znanosti o materialih in metalurgiji • Izbrana poglavja iz modeliranja na mezoskopski prostorski skali: Pottsova Monte Carlo metoda, metoda faznega polja, celični avtomati, topološke mreže ter geometrijski in verteks model, dislokacijski modeli. • Združevanje simulacij na različnih prostorskih in časovnih skalah • Analiza rezultatov simulacij: ravnovesne lastnosti, strukturne lastnosti, dinamične lastnosti, vizualizacija. | • Constitutive modeling of materials at various time and spatial scales. MACROmechanical constitutive models, MICROmechanical constitutive models and representative volume elements for composite and porosity materials, models for analysis of phenomena on NANO scales. • Methods for spatial and time discretization nonlinear problems: selected topics for advanced M5 analysis using finite element methods (FEM) and discrete element method (MDE). • Selected topics in the field of modern materials modelling on atomistic level and implementation of computational atomistic methods in materials science and metallurgy. • Selected topics in the field of modern materials modelling on mesoscopic spatial scale: Potts Monte Carlo methods, phase field methods, cellular automata, topological networks, vertex and geometrical models, dislocation models. • Multiscale modelling: Linking simulations of processes taking place at different time and spatial scales. • Analysis of the results of simulations: equilibrium properties, structural properties, dynamical properties, visualization. |

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| Temeljna literatura in viri/Readings: |
| [1] O. C. Zienkiewicz, R. Taylor, The Finite Element Method, Vol. 1, 2 (fourth edition), McGraw-Hill, London, 1991. [2] K.J. Bathe, Finite Element Procedures, Prentice Hall, New Jersey, 1996. [3] J. Bonet, R.D Wood, Nonlinear Continuum Mechanics for Finite Element Analysis, Cambridge University Press, Cambridge, 1997. [4] M. A. Crisfield, Non-Linear Finite Element Analysis of Solids and Structures, Vol. 1, John Wiley & Sons, Chichester, 1991. [5] M. A. Crisfield, Non-Linear Finite Element Analysis of Solids and Structures, Vol. 2, John Wiley & Sons, Chichester, 1997. [6] J. Bonet, R.D Wood, Nonlinear Continuum Mechanics for Finite Element Analysis, Cambridge University Press, Cambridge, 1997. [7] M. Kleiber, H. Antunez, T. D. Hien, P. Kowalczyk, Parameter Sensitivity in Nonlinear Mechanics – Theory and Finite Element Computations, John Wiley & Sons, Chichester, 1997. [8] Dierk Raabe, Computational Materials Science, Wiley-VCH Verlag GmbH, Weinheim, 1998. [9] Raabe, Dierk, Roters, Franz, Barlat, Frédéric, Chen, Long-Qing (eds.), Continuum Scale Simulation of Engineering Materials: Fundamentals - Microstructures - Process Applications, Wiley-VCH Verlag GmbH, Weinheim, 2004. [10] Koenraad Janssens, Dierk Raabe, Ernest Kozeschnik, Mark Miodownik, Britta Nestler, Computational Materials Engineering, Academic Press, Amsterdam, 2007. [11] Wolfgang Pfeiler (ed), Alloy Physics: A Comprehensive Reference, Wiley-VCH Verlag GmbH, Weinheim, 2007. [12] Specialirizirane monografije za posamezna področja ter novejši članki iz znanstvenih revij. |

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| Cilji in kompetence: | Objectives and competences: |
| Poglobljeno poznavanje izbranih področij, ki so potrebna za razvoj celostnih in poglobljenih M5 računalniških modelov za analize procesov v materialih med mehanskimi, temperaturnimi, elektromagnetnimi in kemičnimi obremenitvami, ki se pojavijo med preizkušanjem, izdelavo in uporabo materialov. Poimenovanje M5 izvira iz angleščine (Multi-field, Multi-scale, Multi-body, Multi-phase & Multi-objective) in pomeni obravnavo vezanih problemov ob upoštevanju različnih fizikalnih polj na različnih časovnih in dimenzijskih skalah. V povezavi s tem bodo obravnavane tudi metode za nelinearne analize kontaktnih problemov med večjim številom deformabilnih teles in delcev, ki so lahko v različnih faznih stanjih ter formulacije namenskih funkcij za uporabo inverznih in optimizacijskih metod. Kandidat se seznani z modernimi pristopi in metodami, kar ga usposobi tako za njihovo uporabo pri svojem raziskovalnem delu, kot tudi za samostojen razvoj M5 modelov. | Deeper knowledge of selected fields that are necessary for the development of M5 computer models for the analysis and studying of processes which occur in materials during mechanical, temperature, electromagnetic and chemical loadings during testing, production and use of materials. M5 stands for Multi-field, Multi-scale, Multi-body, Multi-phase & Multi-objective and deals with constrained problems considering various physical fields at diffent time and spatial scales.Within the scope of the course also methods for nonlinear analysis of contact problems between large number of deformable bodies and particles which can be in different phase states and formulations of objective functions for implementation of inverse and optimization methods will be presented. Candidates will be introduced into using modern methods which will help them in their research, as well as for autonomous development of M5 models. |

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| Predvideni študijski rezultati: | Intended learning outcomes: |
| Znanje in razumevanje. | Knowledge and understanding. |

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| Metode poučevanja in učenja: | Learning and teaching methods: |
| Uvodna predavanja, priprava, predstavitev in zagovor seminarske naloge, Projektno delo v Laboratoriju za numerična analize in Laboratoriju za preizkušanje materialov ter praktična uporaba metod pri raziskovalnem delu. | Introductory lectures, seminar work, Project work in laboratory for numerical analyses and in the laboratory for material testing. Practical implementation of methods in research work. |

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| Načini ocenjevanja: | Delež/Weight | Assessment: |
| Priprava, predstavitev in zagovor seminarske in projektne naloge | 100,00 % | Preparation, presentation and defence of seminar and project work. |

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| Reference nosilca/Lecturer's references: |
| **prof. dr. Tomaž Rodič:**   1. A. Ibrahimbegovic, I. Gešovnik, D. Markovič, S. Melnyk, & T. Rodič: Shape optimization of two-phase inelastic material with microstructure. Engineering. Computations., 2005, letn. 22, no. 5/6, str. 606-645. 2. I. Doltsinis, T. Rodič, Process Design and Sensitivity Analysis in Metal Forming, Int. J. Numer. Meth. Engng., vol. 45, p.p. 661-692, John Wiley & Sons, 1999. 3. Rodič T. and Gresovnik I.: A computer system for solving inverse and optimization problems. Eng. Comput., vol. 15, no. 7, pp. 893-907, 1998. 4. S. Stupkiewicz, J. Korelc, M. Dutko, T. Rodič, Shape sensitivity analysis of large deformation frictional contact problems. Computer Methods in Applied Mechanics and Engineering, (2002), vol 191/33 pp 3555-3   **prof. dr. Goran Kugler:**   1. G. Kugler, R. Turk: Modeling the dynamic recrystallization under multi-stage hot deformation, Acta Mater., 52 (2004), 4659-4668 2. G. Kugler, R. Turk: Study of the influence of initial microstructure topology on the kinetics of static recrystallization using a cellular automata model, Comp. Mater. Sci., 37, (2006), 284-291 3. M. Terčelj, R. Turk, G. Kugler, I. Peruš: Neural network analysis of the influence of chemical composition on surface cracking during hot rolling of AISI D2 tool steel, Comp. Mater. Sci., 42 (2008), 625-637   **prof. dr. Jože Korelc**   1. N. KRISTANIČ, J. KORELC: Optimization method for the determination of the most unfavorable imperfection of structures. Comput. mech., 42 (2008),859-872 2. B. BRANK, J. KORELC, A. IBRAHIMBEGOVIĆ: Dynamic and time-stepping schemes for elastic shells undergoing finite rotations. Comput. Struct.. 81 ( 2003), 1193-1210 3. M. STADLER, G. HOLZAPFEL, J. KORELC. Cn continuous modelling of smooth contact surfaces using NURBS and application to 2D problems. Int. j. numer. methods eng., 2003,2177-2203 |

# Merski monitoring v geoznanosti Učni načrt predmeta/Course syllabus

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| Predmet: | Merski monitoring v geoznanosti |
| Course title: | Survey Monitoring in Geosciences |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Rudarstvo in geotehnologija (smer) | 1. letnik |  | izbirni |

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| Univerzitetna koda predmeta/University course code: | 0076009 |
| Koda učne enote na članici/UL Member course code: | 778 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 30 | 20 | 10 | 0 | 15 | 75 | 5 |

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| Nosilec predmeta/Lecturer: | Milivoj Vulić |

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| Vrsta predmeta/Course type: | Izbirni / Elective |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
| Ni posebnih pogojev za vključitev. | General admission requirements |

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| Vsebina: | Content (Syllabus outline): |
| 1. Uvod, definicija in koncepti meritev na področju geoznanosti. Definicija geodetskih meritev in definicija rudarskih meritev. Definicija nezveznega (po času) in zveznega merskega monitoringa. 2. Metode rudarskih in geodetskih meritev uporabnih za monitoring. Izbira ustreznih metod spremljanja v rudarstvu in geodeziji za izvedbo meritev 2R in/ali 3R prostora. Določitev primernih senzorjev za posamezno metodo spremljanja (GNSS, Nivel, EOD etc.) 3. Načini upravljanja monitoringa Ustvarjanje virtualnih senzorjev, definicija minimalnega časovnega intervala za dosego zveznosti, način beleženja in zapisovanja podatkov v rudarskih in geodetskih primerih. Obdelava in zbiranje podatkov v podatkovnem centru »in situ«, kontrola meritev »in situ«. Načini komunikacije in krmiljenja podatkovnega centra in baznih senzorjev. 4. Optimizacija monitoringa. Praktična izvedba meritev na terenu. Optimiranje pri rekognosciranju prostorskega problema in rešitve. Optimiranje pri zasnovi opazovalnih mrež. 5. Ocena kakovosti meritev. Uporaba obstoječih algoritmov za oceno kakovosti, točnosti in natančnosti merskega monitoringa. Uporaba funkcij avtokorekcije za izboljšanje meritev na terenu. | 1. Introduction, definition and concepts of surveying in geosciences. Definition of geodesy measurements and definition of mining measurements. Definition of continuous (time) and discontinuous measurements monitoring. 2. Methods of mining and geodetic measurementsuseful for monitoring. Selection of adequate survey methods in mining and geodesy for the execution of measurements in 2R and/or 3R space. Determination of adequate sensors for each survey method (GNSS, Nivel, EOD etc.) 3. Methodology of managing the . Creation of virtual sensors, definition of minimal time interval for achievement of continuity, methods of annotation and recording of data in mining and geodesy cases. Processing and collection of data in “in situ” data centre and “in situ” control of measurements. 4. Optimisation of monitoring. Practical execution of measurements in the field. Optimisation during space problem recognition and solutions. Optimisation in design of the survey networks. 5. Quality assessment of surveying. Use of existing algorithms for the assessment of quality, punctuality and precision of the monitoring survey. Use of functions for self-correction for the improvement of field measurements. |

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| Temeljna literatura in viri/Readings: |
| 1. Patarić: rudarsko merenje 1 2. Mihailović: geodezija II (prvi in drugi del) 3. C.M.R. Fowler: the solid earth. an introduction to global geophysics, Cambridge university press, 472 pp., 1990; 4. P. Kaerey, M. Brooks: an introduction to geophysical exploration, 2nd ed, Blackwell Science, 254 pp., 1991; 5. J.M. Reynolds: an introduction to applied and environmental geophysics, John Wiley & Sons, 796 pp., 1997; 6. Vulić, Milivoj, Vulić, Milivoj (ur.). Metoda najmanjših kvadratov : [znanstvena monografija]. 1. izd. Ljubljana: Naravoslovnotehniška fakulteta, Oddelek za geotehnologijo in rudarstvo, 2007. 227 str. ISBN 978-961-6047-49-4. 7. Gosar, Andrej, Ravnik, Danilo. Uporabna geofizika. 1. izd. Ljubljana: Naravoslovnotehniška fakulteta, Oddelek za geotehnologijo in rudarstvo, 2007. IX, 218 str., ilustr. 8. Vižintin, Goran, Rošer, Janez (ur.). Hidravlika kaptažnih objektov podzemne vode in črpalnih poskusov v geoinženirstvu in geotehnologiji: kamnine z medzrnsko poroznostjo: i. del. Ljubljana: Naravoslovnotehniška fakulteta, Oddelek za geotehnologijo in rudarstvo, Katedra za rudarsko merjenje in geofizikalno raziskovanje, 2008. 128 str., ilustr. |

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| Cilji in kompetence: | Objectives and competences: |
| Študenti bodo pridobili znanja o konceptih, metodologiji in praktični uporabi merskega monitoringa v geoznanosti in izvedbi meritev v uporabni geofiziki. Posebna pozornost bo namenjena načrtovanju monitoringa in geofizikalnih meritev, s posebnim poudarkom na podpodročjih geoznanstvene stroke, ki se nanašajo na slušateljska področja strokovnega zanimanja. V okviru predmeta bo slušateljem omogočeno teoretično in praktično spoznavanje z merskim monitoringom in geofizikalnimi meritvami, ki bo posebej prilagojeno interesom slušateljev. Kljub temu, da bo predmet močno projektno usmerjen bo v predmetu tudi del vsebin, ki bodo slušateljem omogočale spoznavanje z osnovami monitoringa v geoznanosti in osnovami geofizikalnih meritev. Tako bo posebna pozornost namenjena praktičnemu pridobivanju podatkov z izvedbo merskih meritev v naravi, kot so na primer meritve premikov točk na površini in v podzemnih prostorih, meritev za določanje geološke strukture in lastnosti kamnin, med katere uvrščamo seizmične, geoelektrične, elektromagnetne, magnetometrične, gravimetrične, geotehnične in karotažne meritve v vrtinah, meritve za določanje hidrodinamičnih in fluidodinamičnih lastnosti kolektorskih plasti nafte, plina in geotermalne vode ter podzemne vode v vodonosnikih. Slušatelji bodo tako najprej spoznali teoretične osnove za optimiranje meritev v naravi, način izvedbe meritev in kontrolo kakovosti meritev. | Students will acquire the knowledge of concepts, methodology and practical application of survey monitoring in geosciences and will be able to carry out measurements in applied geophysics. Special attention will be paid to planning monitoring and geophysical surveying with special focus on sub-fields of geosciences of professional interest to the students. Students will acquire theoretical and practical knowledge in survey monitoring and geophysical surveying, which will be adapted to the interest of the students. While the course will be mainly project-oriented, teaching topics will offer fundamentals of monitoring in geosciences and fundamentals of geophysical surveying. Special attention will be given to practical aspects of data collection and implementation of measurements in the field (e.g. surveying of point displacement on the surface and underground spaces, surveying for determining geological structure and properties of rocks, including seismic, geoelectric, electromagnetic, magneto metric, gravimetric, geotechnical and well loggings in boreholes, measurements for determining hydrodynamic and fluid-dynamic properties of oil, gas and geothermal water layers and underground waters in waterbeds. Thus, students will be first presented with theoretical principles for the optimisation of surveying in the field and how to practically carry out measurements and perform quality assessment procedures. |

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| Predvideni študijski rezultati: | Intended learning outcomes: |
| Znanje in razumevanje. | Knowledge and understanding. |

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| Metode poučevanja in učenja: | Learning and teaching methods: |
| Predavanja v predavalnici z uporabo sodobnih metod poučevanja, predstavitve z računalnikom, praktični primeri. Kabinetna in terenska seznanitev s problemom in izbira primerne metode meritev. Izvedba meritev na terenu. Kontrola kakovosti meritev. | Traditional lecturing by the use of modern teaching methods, computer presentations, practical examples. Presentation of the problems through lectures and in the field, and selection of appropriate surveying methods. Implementation of measurements in the field. Quality control in surveying. |

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| Načini ocenjevanja: | Delež/Weight | Assessment: |
| Obveznost študenta bo izdelava samostojne seminarske naloge, ki predstavlja samostojno raziskovalno delo študenta. Poleg seminarske naloge bo študent moral pripraviti poročilo o izvajanju terenskih vaj. | 100,00 % | Preparation of a seminar work as an independent research project. The project  will be presented during seminar hours and submitted as a  written   scientific report.  Students will also need to submit a report on field work exercises. |

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| Reference nosilca/Lecturer's references: |
| 1. VULIĆ, Milivoj, BLAGOJEVIĆ, Dragan. Recent vertical crustal movements of a part of the Balkan peninsula derived from levelling data. Surv. rev. - Dir. Overseas Surv., July 2008, vol. 40, no. 309, str. 235-243. [COBISS.SI-ID 817503]  2. GANIĆ, Aleksandar, VULIĆ, Milivoj, RUNOVC, Franc, HABE, Tina. The possibiltiy of using homogeneous (projective) coordinates in 2D measurement exercises = možnost uporabe homogenih (projektivinih) koordinat v dvodimenzionalnih merskih nalogah. RMZ-mater. geoenviron., 2008, vol. 55, no. 1, str. 111-126. [COBISS.SI-ID 695902] |

# Metalurgija jekel in kovin Učni načrt predmeta/Course syllabus

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| Predmet: | Metalurgija jekel in kovin |
| Course title: | Metallurgy of Steel and Metals |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 1. letnik |  | izbirni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 1. letnik |  | izbirni |

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| Univerzitetna koda predmeta/University course code: | 0076037 |
| Koda učne enote na članici/UL Member course code: | 772 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 30 | 45 | 0 | 0 | 0 | 75 | 5 |

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| Nosilec predmeta/Lecturer: | Jožef Medved, Matjaž Knap, prof. dr. Jan Falkus |

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| Vrsta predmeta/Course type: | Izbirni / Elective |

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| Jeziki/Languages: | Predavanja/Lectures: | Angleščina, Slovenščina |
|  | Vaje/Tutorial: | Angleščina, Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
| Splošni pogoji določeni s statutom Univerze v Ljubljani in Oddelka za materiale in metalurgijo, Naravoslovnotehniške fakultete Poznavanje višje- in visokotemperaturnih procesov in uporabe fizikalnokemičnih zakonitosti pri teh temperaturah. | General admission requirements according to the Statute of UL; Knowledge of high temperature processes and physical and chemical laws at high temperatures. |

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| Vsebina: | Content (Syllabus outline): |
| V temeljnem in temeljno aplikativnem raziskovanju imajo materiali pomembno mesto, ker so gibalo družbe. Posebno mesto med njimi, na področju znanosti in procesne tehnike, pa zavzemajo kovinski materiali. V to skupino spadajo jekla, neželezne (barvne) kovine in zlitine, čiste kovine in področje redkih kovin. Tak status imajo kovinski materiali zaradi njihove vsestranske uporabnosti, še zlasti pri ustvarjanju sonaravnega razvoja. To zahteva skrajšanje procesov, manjšo porabo energije, visoko produktivnost, okolju prijazne končne proizvode vključno z vmesnimi proizvodi, znižanje oz. preprečevanje škodljivih trdnih, tekočih in plinastih izpustov. Legirana jekla oziroma jekla s posebnimi uporabnimi lastnostmi, ki jih pridobijo z dodatki legirnih elementov so nepogrešljiv in zato tudi vedno nov material pri sonaravnem razvoju, ker lahko zadovolji vse zahteve pri načrtovanju in uporabi novih proizvodnih sistemov. To pa je cilj vseh razvojnih področij.  Faze procesa, ki odločilno vplivajo na kakovost izdelanega kovinskega materiala so: - lastnosti primarnih in sekundarnih surovin, - taljenje, redukcija, oksidacija, topnost posameznih legirnih elementov in zlitin ter njihov izkoristek,  - topnost kisika in dezoksidacija, - tvorba oksidnih in neoksidnih sistemov v tekoči kovini in zlitini ter modifikacija nekovinskih vključkov, - reakcije na fazni meji med žlindro in kovino, razfosforenje, razžveplanje, reakcije med ognjevzdržnim materialom, tekočo žlindro in kovino, - transportni pojavi v mirujočih in gibajočih talinah in žlindrah, - modeliranje jeklarskih procesov in procesov pri proizvodnjih neželeznih kovin in zlitin, - interakcije na mirujočih in gibajočih faznih mejah v jeklarskih talinah in talinah neželeznih kovin, tvorba emulzije med kovinsko in nekovinsko talino, tvorba mirujočih (mrtvih) in gibajočih talin v reaktorjih, - struktura kovinskih talin, - sestava in lastnosti izhajajočih plinov, tvorba prahov in njihovo recikliranje, - procesi razplinjanja talin, - taljenje in raztapljanje legirnih elementov v kovinskih talinah, - sekundarni rafinacijski procesi v različnih reaktorjih, - rafinacijski procesi med vlivanjem in strjevanjem jekla, kovin in zlitin v kristalizatorjih in kokilah, - proizvodni sistemi in njihov razvoj, posebne procesne tehnike. | Materials play an important role in fundamental and applied research since they are carriers of social development. Metals, which include steels, non-ferrous metals and alloys, pure metals and rare-earth metals have special place in science and process engineering research. This special status of metals is due to their universal applicability, particularly for sustainable development. Sustainable development demands reducing the production processes and energy consumption, higher productivity, environmentally friendly products and by-products, reduction or prevention of harmful gaseous, liquid or solid releases. Alloyed steels, or steels with special properties are indispensable for ensuring sustainable development. They can satisfy all the demands in planning and production engineering which is in fact the objective development. Process stages with large impacts on the quality of produced metals are: - properties of primary and secondary raw materials, - melting, reduction, oxidation, solubility and yield of alloying elements and alloys, - oxygen solubility and deoxidation, - formation of oxide and non-oxide systems in liquid metal or alloy and modification of non-metal inclusions, - reaction on slag – metal interface, desulphurization, reaction between refractory material, liquid slag and metal, - transportation phenomena in stationary and moving melts and slags, - modelling of steelmaking processes and of processes in the production of non-ferrous metals and alloys, - interaction on motionless and moving interfaces in melts of steel and non-ferrous metals and alloys, formation of emulsion between metal and non-metal melt, formation of stationary and moving melts in reactor, - microstructure of metal melts, - composition and properties of exhaust gases, formation of dusts and dust recycling, - processes of melt degassing, - dissolving and melting of alloying elements in metal melts, - secondary refining processes in various reactors, - refining processes during pouring and solidification of steel, non-ferrous metals and alloys in moulds and ingot moulds, - steel and non-ferrous metal production techniques and their development, special production techniques. |

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| Temeljna literatura in viri/Readings: |
| Seshardi Seetharman: Fundamentals of metallurgy, Woodhead Publishing Limited, Cambridge England (2005) Ahindra Ghosh: Secondary steelmaking: Principles and Applications, CRC Press, Boca Raton (2001) U. Kamachi Mudali, Baldev Raj: High Nitrogen Steels and Steinless Steels. Alpha Science International Ltd. Pangbourne UK (2004) Aktualni članki v revijah kot so / Up to date articles in: Metallurgical and Materials Transactions A, Metallurgical and Materials Transactions B, ISIJ International, International Journal of Iron and Steel Research, Stahl und Eisen itd. |

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| Cilji in kompetence: | Objectives and competences: |
| Doktorski študij je namenjen ustvarjanju novega znanja, zato so izobraževalni cilji postavljeni tako, da bo študentu oziroma udeležencem tega študija obravnavana snov predstavljena tako, da bo pri njih vzbudila raziskovalni in razvojni pristop, k poglabljanju znanja in iskanju novih rešitev na posameznih specifičnih področjih jekel in kovin. Študenti bodo pridobili toliko teoretičnih znanj, da bodo lahko razvijali novo temeljno znanje, ki je predpogoj za razvijanje novih znanj (doprinos k znanosti) in tudi aplikacij v življenjskem ciklu materialov. Glavni cilj tega predmeta je pripraviti študenta, da bo sam razvijal temeljne inovativne faze procesov in dobil sposobnost prenašati raziskovalne rezultate v uporabo in njihovo komercializacijo. | Learning outcomes (competences): deepening of already acquired knowledge, stirring up research and active engagement in the particular scientific problem which will lead to new solutions in the research field of steel and metals. Students will get sufficient theoretical background to be able to expand new fundamental knowledge (scientific contribution) for development of new technologies in life cycle of materials. The main objective of this course is to prepare students to develop basic innovative solutions at different process stages, and to be able to transfer results into practice and further on to product commercialisation. |

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| Predvideni študijski rezultati: | Intended learning outcomes: |
| Znanje in razumevanje. | Knowledge and understanding. |

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| Metode poučevanja in učenja: | Learning and teaching methods: |
| Ker gre za doktorski študij je, v sodelovanju z mentorjem, poudarek na individualnem delu z doktorandom. V obvezni organizirani obliki doktorskega študija bodo metode poučevanja in učenja potekale z uporabo predavanj, vaj, seminarjev in individualnih konzultacij. Na osnovi interesa študenta, povezanega z doktorsko nalogo ali razširitev znanja iz tega področja, se bodo pripravila področja seminarskega dela, ki ga študent samostojno pripravlja s pomočjo mentorja in ga predstavi v obliki krajšega predavanja pred ostalimi slušatelji. | The main stress is on individual work with students, in agreement with their mentor. The obligatory (organized) part of the study will consists of the following methods: lectures, exercises, seminars and individual consultations. The topic for seminar work will be chosen on the basis of student’s interest and should be related to the topic of doctoral thesis. Seminar work is carried out on individual basis under mentorship. Students will present the results to other students in the form of a short lecture. |

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| Načini ocenjevanja: | Delež/Weight | Assessment: |
| Ocena je sestavljena iz ocene seminarja in ocene ustnega izpita. | 100,00 % | Final grade is a combination of the grade  for the seminar and oral exam. |

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| Reference nosilca/Lecturer's references: |
| **doc. dr. Matjaž KNAP**  KNAP, Matjaž, LAMUT, Jakob. Prediction of steel grade on basis of chemical composition. V: KOSTOV, Ana (ur.), LJUBOJEV, Milenko (ur.). 41st International October Conference on Mining and Metallurgy - IOCMM 2009, Kladovo, 4th - 6th October 2009. Proceedings. Bor: Mining and Metallurgy Institute, 2009, str. 751-756. [COBISS.SI-ID 973407]  KNAP, Matjaž, FALKUS, Jan, ROZMAN, Alojz, LAMUT, Jakob. The prediction of hardenability using neuronal networks = Symulacja hartowności oparta o zastosowanie sztucznych sieci neuronowych. Archives of metallurgy and materials, 2008, vol. 53, no. 3, str. 761-766. http://www.imim.pl/archives. [COBISS.SI-ID 913759]  KNAP, Matjaž, LAMUT, Jakob. Fizikalno simuliranje procesov v metalurških reaktorjih. V: LAMUT, Jakob (ur.). 10. seminar o procesni metalurgiji jekla. Ljubljana: NTF, Odd. za mat. in tehnologijo, 2005, 2005, 9 str.(loč. pag.), ilustr. [COBISS.SI-ID 552287]  **prof. dr. Jan Falkus:**  FALKUS J., T. Kargul, P. Drozdz. A new method for determining chemical composition of refining slag in the ladle furnace. Molten 2009: proceedings of the VIII. International conference on molten slags, fluxes and salts, Santiago, Chile, 18-21 January 2009. Santiago: Gecamin, 2009  DROŻDŻ, P. FALKUS J.. The modeling of vacuum steel refining in the RH degassing unit based on thermodynamic analysis of the system — Modelowanie procesu próżniowej rafinacji stali w urządzeniu RH w oparciu o analizę termodynamiczną Archives of Metallurgy and Materials Polska Akademia Nauk. Komitet Metalurgii, Kraków, Polska Akademia Nauk. Instytut Metalurgii i Inżynierii Materiałowej im. Aleksandra Krupkowskiego, Kraków ; ISSN 1733-3490. — 2007 vol. 52 iss. 4 s. 585–591. — Bibliogr. s. 591  FALKUS, J., PIETRZKIEWICZ, P., PIETRZYK, W., KUSIAK., J. Application of an artificial neural network to the control of an oxygen converter process W: Intelligence in a small materials world : selected papers from IPMM-2003 the fourth international conference on Intelligent processing and manufacturing of materials eds. John A. Meech [et al.]. — Lancaster, Pennsylvania, U. S. A. : DES{\it tech} Publications, Inc., 2005. — S. 149–159. — Bibliogr. s. 158–159, Abstr.  **prof. dr. Jožef Medved:**  MEDVED, Jože, MRVAR, Primož, PAPEŽ, Anton, RUS, Brane. Strjevanje zlitin Mg-Al = Solidification of Mg-Al alloys. *Livar. vestn.*, 2005, let. 52, zv. 2, 66-77 str.  MEDVED, Jože, KORES, Stanislav, MRVAR, Primož, VONČINA, Maja. Železo v aluminijevih zlitinah = Iron in aluminium alloys. *Livar. vestn.*, 2008, letn. 55, št. 3, str. 126-140.  MRVAR, Primož, TRBIŽAN, Milan, MEDVED, Jože. Spremljanje strjevanja železovih litin z dilatometrijo = Investigation of cast iron solidification with dilatation analysis. *Kovine zlit. tehnol.*, 1999, letn. 33, št. 1/2, str. 45-49, ilustr. |

# Metode napovedovanja sprememb v zemeljski skorji Učni načrt predmeta/Course syllabus

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| Predmet: | Metode napovedovanja sprememb v zemeljski skorji |
| Course title: | Methods of Predicting Changes in the Earth Crust |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Rudarstvo in geotehnologija (smer) | 1. letnik |  | izbirni |

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| Univerzitetna koda predmeta/University course code: | 0076010 |
| Koda učne enote na članici/UL Member course code: | 779 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 25 | 25 | 25 | 0 | 0 | 75 | 5 |

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| Nosilec predmeta/Lecturer: | Andrej Gosar, Goran Vižintin, Milivoj Vulić |

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| Vrsta predmeta/Course type: | Izbirni / Elective |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
| Splošni pogoji UL za vpis na doktorski študij. | General admission requirements |

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| Vsebina: | Content (Syllabus outline): |
| 1. Uvod, definicija in koncepti modelov na področju geoznanosti. Direktno in inverzno modeliranje v geoznanosti (geofiziki, geodeziji, rudarskem merjenju in podzemnih fluidih). 2. Pregled metod predikcije v okolju. Gravimetrične, magnetometrične, geoelektrične in seizmične metode pri napovedovanju sprememb v okolju. Geotermija in geofizikalna karotaža. Monitoring sprememb v okolju, ki so posledica izkoriščanja energetskih virov in naravnih surovin z geofizikalnimi metodami. Monitoring širjenja onesnaženja z geofizikalnimi metodami. Spremljanje in predikcija ugrezanja, položajnega in 3R premika. Monitoring hitrosti sprememb lege in deformacij ter predikcija konsolidacije terena v 1, 2 in 3R prostoru. Spremljanje in predikcija tlakov in ostalih fizikalnih parametrov zemeljskih fluidov (nafta, plin, geotermalna voda) 3. Analitični modeli. Modeliranje podatkov vertikalnega električnega sondiranja in kartiranja. Sintetični seizmogrami v refleksijski seizmiki. Modeliranje 1, 2, 3R velikosti in hitrosti deformacij. 1, 2 in 3 R analitično modeliranje porazdelitve fizikalnih lastnosti podzemnih fluidov. 4. Numerični modeli. 2R in 3R modeliranje težnostnih in magnetometričnih podatkov. 2R modeliranje podatkov geoelektrične tomografije. Seizmična tomografija, seizmično modeliranje z metodo sledenja žarkov. Modeliranje georadarskih podatkov. Numerično modeliranje zahtevnejših prostorskih deformacij na območjih pod vplivom posegov v prostor. Modeliranje prenosa snovi in toplote, s pomočjo 3R modelov (končne diference in končni elementi). 5. Predstavitev podatkov v prostoru. Načini predstavljanja geodetskih, mersko rudarskih, geofizikalnih in drugih geopodatkov podatkov: 1R, 2R in 3R. Metode interpolacij površin. Predstavljanje časovno spremenljivih geodetskih, mersko rudarskih, geofizikalnih in drugih geopodatkov podatkov: 4R. 6. Analiza in ocena kakovosti predikcij, ocena točnosti in natančnosti a priori in a posteriori. Verifikacija geodetskih, mersko rudarskih, geofizikalnih in drugih geo - modelov s podatki vrtanja in drugimi geološkimi podatki. | 1. Introduction, definition and concept models in the field of geosciences. Direct and inverse modelling in geosciences (geophysics, geodesy, mining measurements and underground fluids). 2. Prediction methods related to environment. Gravimetry, magnetometry, geoelectrical and seismic methods in prediction of changes in the environment. Geothermy and geophysical well-logging. Monitoring of environmental changes caused by exploitation of energy resources and raw materials through the use of geophysical methods. Monitoring of pollution by geophysical methods. Monitoring and prediction of sinking, positional and 3R shift. Monitoring of the speed of position shift and deformation, and prediction of terrain consolidation in 1, 2 and 3R space. Monitoring and prediction of pressures and other physical parameters in geofluids (oil, geothermal water). 3. Analytical models. Modelling data of vertical electric sounding and mapping. Synthetic seismograms in seismic reflection. Modelling of 1, 2 and 3R sizes and deformation speeds. Analytical modelling in 1, 2 and 3R for distribution of physical properties of underworld fluids. 4. Numerical models. 2R and 3R modelling of gravity and magnetometric data. 2R modelling of geoelectric tomography data. Seismic tomography, seismic modelling using the method of ray-tracing. Modelling of georadar data. Numerical modelling of complex space deformations in areas influenced by exploitation. Modelling of the mass and heat transfer with help of 3R models (finite differences and finite elements). 5. Presentation of data in space. Methods of presenting geodetic, mining-surveying, geophysical and other geo-data: 1R, 2R and 3R. Methods of surface interpolation. Presentation of time-dependant geodetic, mining-surveying, geophysical and other geo-data: 4R. 6. Analysis and assessment of quality in predictions, assessment of punctuality and precision »a priori« and »a posteriori.« Verification of geodetic, mining-surveying, geophysical and other geo-models through the use of drilling data and other geological data. |

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| Temeljna literatura in viri/Readings: |
| 1. Patarić: rudarsko merenje 1 2. Mihailović: geodezija II (prvi in drugi del) 3. C.M.R. Fowler: The solid earth. an introduction to global geophysics, Cambridge university press, 472 pp., 1990; 4. P. Kaerey, M. Brooks: An introduction to geophysical exploration, 2nd ed, Blackwell Science, 254 pp., 1991; 5. J.M. Reynolds: An introduction to applied and environmental geophysics, John Wiley & Sons, 796 pp., 1997; 6. Vulić, Milivoj, Vulić, Milivoj (ur.). Metoda najmanjših kvadratov : [znanstvena monografija]. 1. izd. Ljubljana: Naravoslovnotehniška fakulteta, Oddelek za geotehnologijo in rudarstvo, 2007. 227 str. ISBN 978-961-6047-49-4. 7. Gosar, Andrej, Ravnik, Danilo. Uporabna geofizika. 1. izd. Ljubljana: Naravoslovnotehniška fakulteta, Oddelek za geotehnologijo in rudarstvo, 2007. IX, 218 str., ilustr. 8. Vižintin, Goran, Rošer, Janez (ur.). Hidravlika kaptažnih objektov podzemne vode in črpalnih poskusov v geoinženirstvu in geotehnologiji: kamnine z medzrnsko poroznostjo:i. del. Ljubljana: Naravoslovnotehniška fakulteta, Oddelek za geotehnologijo in rudarstvo, Katedra za rudarsko merjenje in geofizikalno raziskovanje, 2008. 128 str., ilustr. |

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| Cilji in kompetence: | Objectives and competences: |
| Meritve pridobljene v okviru geofizikalnih in geotehnoloških ved morajo biti ustrezno analizirane in uporabljene za predikcijo stanj v okolju. Prav zato bodo študenti v okviru tega predmeta pridobili potrebna znanja o konceptih, metodologiji in praktični uporabi napovedovanja sprememb v okolju, na osnovi geofizikalnih in geotehnoloških meritev. Posebna pozornost bo namenjena analizi rezultatov monitoringa s posebnim poudarkom na oceni kakovosti napovedanih sprememb v okolju. Napovedi se bodo izvajale na osnovi praktično pridobljenih podatkov, ki bodo pridobljeni v realnem geookolju in kot rezultat ciljnih projektnih meritev na področju geotehnoloških in geofizikalnih ved. Posebna pozornost bo namenjena izdelavi napovedi sprememb v geookolju, ki se izdelujejo kot posledica slovenske zakonodaje in EU zahtev. Slušatelji bodo seznanjeni s predpisi in drugimi pravnimi akti, ki definirajo in zahtevajo napovedi o stanju v okolju tako na kratkoročnem, srednjeročnem in dolgoročnem nivoju. Slušatelji bodo pridobili znanja, ki jim bodo omogočala oceno zanesljivosti predikcije in predstavitev rezultatov v okolju. | Measurements in geophysics and geotechnology need to be suitably carried out and analysed in order to be used for the prediction of activities in the environment. Students will acquire knowledge of concepts, methodology and practical use of data obtained from geophysical and geotechnological surveying. Special attention will be paid to the analysis of monitoring, with a special emphasis on the quality assessment of predicted changes. Predictions will be carried out on the basis of practically obtained data from a real geological environment, and as a result of geophysical and geotechnological project measurements. Special attention will be paid to predicting changes in a particular geological environment which is required by national and European legislation. Students will learn about other legal acts and regulations which require identification of the conditions in the environment and predictions on a short-term and long-term basis. Students will also acquire knowledge for making assessment about the accuracy of the predictions and possible effects on the environment. |

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| Predvideni študijski rezultati: | Intended learning outcomes: |
| Znanje in razumevanje: konceptov modelov v geoznanosti, metod napovedovanja sprememb v zemeljski skorji, analitičnih modelov, numeričnih modelov, predstavitev podatkov v prostoru, analiz in ocene kakovosti napovedi. | Knowledge and understanding: concepts of models in geoscience, methods of predicting changes in Earth crust analythic models, numerical models, presentation of data in space, analysis and assessment of quality in predictions. |

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| Metode poučevanja in učenja: | Learning and teaching methods: |
| Predavanja v predavalnici z uporabo sodobnih metod poučevanja, predstavitve z računalnikom, praktični primeri. Kabinetna in terenska seznanitev s problemom in izbira primerne metode meritev. Izvedba meritev na terenu. Kontrola kakovosti meritev. | Lecturing through the use of modern equipment, computer presentations, practical examples. Theoretical and practical presentation of the problems and selection of suitable surveying methods. Implementation of measurements in the field. Quality control of surveys. |

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| Načini ocenjevanja: | Delež/Weight | Assessment: |
| Obveznost študenta bo izdelava samostojne seminarske naloge, ki predstavlja samostojno raziskovalno delo študenta. Poleg seminarske naloge bo študent moral pripraviti poročilo o izvajanju terenskih vaj. | 100,00 % | Seminar work, which will demonstrate autonomous research work of the students. Students will also need to submit a report on field work. |

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| Reference nosilca/Lecturer's references: |
| doc. dr. Goran Vižintin  1) VIŽINTIN, Goran, RAVBAR, Nataša, JANEŽ, Jože, KOREN, Eva, JANEŽ, Naško, ZINI, Luca, TREU, Francesco, PETRIČ, Metka. Integration of models of various types of aquifers for water quality management in the transboundary area of the Soča/Isonzo river basin (Slovenia/Italy). *Science of the total environment*, ISSN 0048-9697, 1. Apr. 2018;  2) VUKELIČ, Željko, DERVARIČ, Evgen, ŠPORIN, Jurij, VIŽINTIN, Goran. The development of dewatering predictions of the Velenje coalmine. *Energies*, ISSN 1996-1073, 2016; UHAN, Jože, VIŽINTIN, Goran, PEZDIČ, Jože. Groundwater nitrate vulnerability assessment in alluvial aquifer using proces-based models and weihgts-of-evidence method : lower Savija valley case study (Slovenia). *Environmental earth sciences*, ISSN 1866-6280, 2011;  3) VIŽINTIN, Goran, SOUVENT, Petra, VESELIČ, Miran, ČENČUR CURK, Barbara. Determination of urban groundwater pollution in alluvial aquifer using linked process models considering urban water cycle. *Journal of Hydrology*, ISSN 0022-1694. [Print ed.], 2009  4) SOVIČ, Nataša, VIŽINTIN, Goran, LAPAJNE, Slavko, VESELIČ, Miran. Hydrological effect on the chemical status of groundwater. *Acta chimica slovenica*, ISSN 1318-0207. [Tiskana izd.], 2007;  **izr. prof. dr. Milivoj Vulić**  1) HONUS, Stanislav, BOCKO, Peter, BOUDA, Tomáš, RISTOVIĆ, Ivica, VULIĆ, Milivoj. The effect of the number of conveyor belt carrying idlers on the failure of an impact place : a failure analysis. Engineering failure analysis, ISSN 1350-6307. [Print ed.], 2017;  2) ŠKRJANC, Žiga, VULIĆ, Milivoj. Comparison of the directional survey calculation methods applied on real well data. Measurement : journal of the International Measurement Confederation, ISSN 0263-2241. [Print ed.], 2016;  3) BORISOV, Mirko, PETROVIĆ, Vladimir, VULIĆ, Milivoj. Optimal map conic projection : a case study for the geographic territory of Serbia = Optimalna kartografska konična projekcija : analiza slučaja za geografski teritorij Srbije. Tehnički vjesnik : znanstveno-stručni časopis tehničkih fakulteta Sveučilišta u Osijeku, ISSN 1330-3651, 2015;  4) ČERU, Teja, ŠEGINA, Ela, KNEZ, Martin, BENAC, Čedomir, GOSAR, Andrej. Detecting and characterising unroofed caves by ground penetrating radar. *Geomorphology : an international journal of pure and applied geomorphology*, ISSN 0169-555X.;  **prof. dr. Andrej Gosar**  1) ČERU, Teja, DOLENEC, Matej, GOSAR, Andrej. Application of ground penetrating radar supported by mineralogical-geochemical methods for mapping unroofed cave sediments. *Remote sensing*, ISSN 2072-4292.;  2) MATOŠ, Bojan, ZAJC, Marjana, KORDIĆ, Branko, TOMLJENOVIĆ, Bruno, GOSAR, Andrej. Quaternary fault activity in the SW Pannonian Basin : GPR surveying in Bilogora (NE Croatia). *Geological Quarterly*, ISSN 1641-7291, 2017 |

# Mikroskopija materialov Učni načrt predmeta/Course syllabus

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| Predmet: | Mikroskopija materialov |
| Course title: | Microscopy of Materials |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 1. letnik |  | izbirni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 1. letnik |  | izbirni |

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| Univerzitetna koda predmeta/University course code: | 0076038 |
| Koda učne enote na članici/UL Member course code: | 764 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 45 | 30 | 0 | 0 | 0 | 75 | 5 |

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| Nosilec predmeta/Lecturer: | Janez Dolinšek |

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| Vrsta predmeta/Course type: | Izbirni / Elective |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
| Vpis v letnik. | General admission requirements. |

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| Vsebina: | Content (Syllabus outline): |
| I. Vrstični elektronski mikroskop in mikroanaliza (SEM): Zgodovinski pregled, vrstični elektronski mikroskop in mikroskopija (SEM), elektronska mikrosonda in mikroanaliza (EPMA), elektronske puške, izvor s poljsko emisijo, kolona in elektromagnetne leče v SEM, interakcija med elektronskim snopom in vzorcem, formiranje slike v SEM, energijska disperzijska spektroskopija (EDS), valovna diperzijska spektroskopija (WDS), kvalitativna rentgenska analiza, korekcijske metode. II. Presevni (transmisijski) elektronski mikroskop (TEM): Instrumenti in metode na osnovi elektronskega snopa, sestavni deli presevnega elektronskega mikroskopa, priprava vzorcev, elektronska difrakcija, nastanek slike v TEM in vrste kontrasta, osnovno centriranje mikroskop, nastanek slike v TEM (svetlo polje, temno polje, fazni kontrast), elektronska difrakcija izbranega področja, mikrodifrakcija, indeksiranje uklonskih vzorcev ED (monokristalni in praškovni). III. Površinske metode: Vrstična tipalna mikroskopija in spektroskpoija (SPM), mikroskopija na atomsko silo (AFM), vrstična optična mikroskopija v bližnjem polju (SNOM), vrstična tunelska mikroskopija (STM), površinska kristalografija: nizko-energijski elektronski uklon (LEED), Augerjeva elektronska spektroskopija (AES). | I. Scanning electron microscopy and microanalysis (SEM) II. Transmission electron microscopy (TEM) III. Surface methods (STM, AFM, LEED, AES) |

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| Temeljna literatura in viri/Readings: |
| Transmission Electron Microscopy; D. B. Williams, C. B. Carter (Plenum Press, New York, 1996) Introduction to Surface and Thin Film Processes; J. A. Venables (Cambridge University Press,2000) Surfaces and Interfaces of Solid Materials; H. Lüth (Springer, Berlin, Heidelberg, 1995) |

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| Cilji in kompetence: | Objectives and competences: |
| Spoznavanje mikroskopskih eksperimentalnih metod v raziskavah materialov. | acquiring knowledge on microscopic experimental methods in materials science. |

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| Predvideni študijski rezultati: | Intended learning outcomes: |
| Znanje in razumevanje modernih mikroskopskih metod za raziskave in karakterizacijo materialov. | Knowledge and understanding of modern microscopic methods for the research and characterization of materials. |

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| Metode poučevanja in učenja: | Learning and teaching methods: |
| Predavanja, vaje in projekti, domače naloge in konzultacije. | Lectures, exercises, homework, consultations |

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| Načini ocenjevanja: | Delež/Weight | Assessment: |
| Izpit pisni ali/in ustni. | 100,00 % | written and/or oral exam |

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| Reference nosilca/Lecturer's references: |
| 1. DOLINŠEK, Janez, VRTNIK, Stanislav, KLANJŠEK, Martin, JAGLIČIĆ, Zvonko, SMONTARA, Ana, SMILJANIĆ, Igor, BILUŠIĆ, Ante, YOKOYAMA, Y., INOUE, Akihisa, LANDAURO, C. V. Intrinsic electrical, magnetic, and thermal properties of single-crystalline Al[sub](64)Cu[sub](23)Fe[sub](13) icosahedral quasicrystal: experimental and modeling. Phys. rev., B, Condens. matter mater. phys., 2007, vol. 76, no. 5, str. 054201-1-054201-9.  2. DOLINŠEK, Janez, SLANOVEC, Jernej, JAGLIČIĆ, Zvonko, HEGGEN, M., BALANETSKYY, S., FEUERBACHER, M., URBAN, K. Broken ergodicity, memory effect, and rejuvenation in Taylor-phase and decagonal Al[sub]3(Mn, Pd, Fe) complex intermetallics. Phys. rev., B, Condens. matter mater. phys., 2008, vol. 77, no. 6, str. 064430-1-064430-18.  3. DOLINŠEK, Janez, KOMELJ, Matej, JEGLIČ, Peter, VRTNIK, Stanislav, STANIĆ, Denis, POPČEVIĆ, P., IVKOV, Jovica, SMONTARA, Ana, JAGLIČIĆ, Zvonko, GILLE, Peter, GRIN, Yuri. Anisotropic magnetic and transport properties of orthorhombic Al[sub](13)Co[sub]4. Phys. rev., B, Condens. matter mater. phys., 2009, vol. 79, no. 18, str. 184201-184201-12. |

# Modeliranje odkopnih metod Učni načrt predmeta/Course syllabus

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| Predmet: | Modeliranje odkopnih metod |
| Course title: | Modelling of Coal Mining Technologies |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Rudarstvo in geotehnologija (smer) | 1. letnik |  | izbirni |

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| Univerzitetna koda predmeta/University course code: | 0076011 |
| Koda učne enote na članici/UL Member course code: | 777 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 25 | 25 | 25 | 0 | 0 | 75 | 5 |

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| Nosilec predmeta/Lecturer: | Goran Vižintin, Milivoj Vulić |

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| Vrsta predmeta/Course type: | Izbirni / Elective |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
| Za izbiro predmeta je pogoj znanje iz vsebin predmetov Tehnično rudarstvo I. in II. z magistrskega študijskega programa Geotehnologija in rudarstvo oziroma osvojena primerljiva znanja. | Candidates must demonstrate an appropriate mastery of subject material as per study courses Mining Engineering I and II (Master’s Degree syllabus, Geotechnology & Mining) or mastery of equivalent knowledge and skills. |

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| Vsebina: | Content (Syllabus outline): |
| Vsebinska osnova predmeta je zasnovana na pridobitvi znanja z upoštevanjem specifičnosti in kompleksnosti odkopavanja debelih slojev premoga. V naslednjih sklopih so sistematsko podana vsebine: - Poglobljene analize razumevanja sodobnih širokočelnih metod podzemnega odkopavanja debelih slojev premoga z upoštevanjem metod opazovanj in njihova praktična uporaba - Sistemska obdelava ključnih odkopnih parametrov, njihova analiza in interpretacija - Presoja, vrednotenje in interpretacija ključnih potencialnih nevarnih pojavov v času priprave in eksploatacije - Načrtovanje ciljnih raziskav in opazovanj hribinskih območij z uporabo kritične presoje razpoložljivih metod raziskovanja s prednostmi in omejitvami - Analiza laboratorijskih metod raziskovanja hribin s kritično presojo uporabnosti rezultatov v okviru določanja projektnih parametrov - Inženirska presoja klasifikacij hribin s poudarkom na določanju geomehanskih parametrov hribinskih gmot in širših hribinskih območij - Analiza in kritična presoja geoloških in tehnoloških tveganj pri uporabi različnih metod širokočelnega podzemnega odkopavanja - Sistem parametrizacije vplivnih dejavnikov pri načrtovanju odkopavanja debelih slojev premoga - Selekcija, vrednotenje in statistične analize (korelacijske) posameznih skupin vplivnih dejavnikov - Ekonomske interpretacije izbranih širokočelnih odkopnih metod - Analiza in kritična presoja geoloških, tehnoloških in ekonomskih tveganj pri uporabi izbrane širokočelne odkopne metode - Pregled in presoja ključnih načinov vodenja podzemnega odkopavanja debelih slojev premoga ob upoštevanju principov ekonomičnosti in gospodarnosti ob zagotovljenih predpisanih varnostnih pogojih za področje podzemne eksploatacije Načini načrtovanja in implementacije varnostnih ukrepov z upoštevanjem zakonodaje s področja varnosti in zdravja pri delu. | The course has been designed to provide training and impart knowledge in relation to the specifics and complexity involved in the exploitation of thick coal seams. Syllabus outline: - In-depth analyses and understanding of contemporary longwall coalmining methods (underground mining of thick coal seams) including monitoring methods and their practical applications. - Key mining parameters: systematic processing, analysis and interpretation. - Assessment, evaluation and interpretation of key potential hazards in the course of preliminary works and coal extraction. - Planning target-oriented research and monitoring of rock strata using critical assessment of available research methods including their advantages and disadvantages. - Analysis of laboratory methods used in the study of rock strata, including critical assessment of the usefulness of results when determining project parameters. - Engineering assessment of rock classification with the emphasis on determining the geomechanical parameters of rock strata. - Analysis and critical assessment of geological and technological risks using different underground longwall mining methods. - Parametrisation of key factors involved in the planning of thick coal seam mining. - Selection, evaluation and statistical analyses (correlation) of individual groups of key factors. - Economic interpretation of selected longwall mining methods. - Analysis and critical assessment of geological, technological and economic risks involved in the application of the selected longwall mining method. - An overview and assessment of key methods of managing the underground mining of thick coal seams while taking into account the principles of economy and cost effectiveness and ensuring safety applicable to underground mining. Planning and implementation of safety measures in accordance with the current occupational health and safety legislation. |

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| Temeljna literatura in viri/Readings: |
| B. Hebblewhite, Technology and Feasibility of Potential Underground Thick Seam Mining Methods, New South Wales, Australia, 2002. H. Kratzsch, Mining Subsidence Engineering, Berlin Heidlberg New York, 1983. R. D. Merritt, Coal Exploration, Mine Planning, and Development, Fairbanks, Alaska, 1986. I. C. Runge, Mining Economics and Strategy, Littleton, USA, 1998. Velenjska odkopna metoda, Premogovnik Velenje, 2002 |

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| Cilji in kompetence: | Objectives and competences: |
| /Doktorand je na osnovi svojega predhodnega izobraževanja usposobljen, da samostojno rešuje naloge s področja odkopavanja debelih slojev premoga z uporabo parametričnih in numeričnih modelov za potrebe projektiranja, izvedbe, spremljanja in analiziranja procesov podzemnega pridobivanja premoga. Posebna znanja s področja tehničnega rudarstva mora doktorand znati uporabiti pri zasnovah tehničnih parametrov debelega sloja premoga ob upoštevanju posebnosti hribinskih območij ter temu primerno predvideti sodobno tehnološko osnovo načina odkopavanja. Za kompleksno dojemanje parametrov odkopavanja debelih slojev premoga mora doktorand poznati tudi tehnične in tehnološke značilnosti ležišč in metode vrednotenja vplivnih dejavnikov, geološko geotehnično vrednotenje opazovanih in merjenih parametrov strukturnih, mehanskih in kemičnih lastnosti hribin ter jih znati inženirsko interpretirati. | The candidate will be qualified to independently tackle problems related to thick coal seam mining using parametric and numerical models for the purposes of the design, implementation, monitoring and analysis of processes involved in underground coalmining. In determining technical parameters of thick coal seams, the candidate will need to apply specialised knowledge acquired in the field of mining engineering while taking into account the specifics of the rock strata and adequately propose a contemporary technological basis of coal extraction. In order to be able to grasp the complexity of parameters involved in thick coal seam mining, the candidate should also be familiar with the engineering and technological characteristics of deposits and with assessment and evaluation methods applicable to key factors as well as with the methods of geological geotechnical assessment and evaluation of monitored and measured parameters of the structural, mechanical and chemical characteristics of rock strata, and capable of providing an engineering interpretation thereof. |

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| Predvideni študijski rezultati: | Intended learning outcomes: |
| Znanje in razumevanje: Razumevanje vsebin in napredek pri predmetu zahteva poglobljeno znanje osnovnih strokovnih predmetov kot so mehanika, inženirska geologija, mehanika kamnin, mehanika tal in tehnično rudarstvo, vključno z drugimi inženirskimi predmeti s področja materialov. Napredovanje v znanju pomembnega področja modeliranja različnih odkopnih metod omogoča sinteza znanj več predmetov iz predhodnih semestrov. Posebej se za ta predmet zahteva študentovo interdisciplinarno znanje in organiziranost ter sistematični način dela. To je povezano s prevzemanjem inženirske odgovornosti pri znanstvenem analiziranju ter načrtovanju ali vodenju zahtevnih površinskih in podzemnih rudarskih del. | Knowledge and understanding: Understanding the content and progress of the present course requires detailed knowledge of basic professional courses such as mechanics, engineering geology, rock and soil mechanics and mining engineering, including other fields of engineering materials. Advancement in knowledge of key areas of underground constructions topic allows the synthesis of several subtopics of knowledge from previous semesters. Especially for this course requires the student's interdisciplinary knowledge, organizational and systematic approach to study. This is linked with the engineering responsibilities in the scientific analysis and planning or managing of complex surface and underground mining operations. |

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| Metode poučevanja in učenja: | Learning and teaching methods: |
| Konzultacije, strokovna literatura, študij primerov dobre prakse, numerično modeliranje podzemnih gradenj na konkretnih primerih. | Consultations, reading professional literature, best practice case studies, numerical modelling of specific underground construction projects. |

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| Načini ocenjevanja: | Delež/Weight | Assessment: |
| Izdelava in predstavitev seminarske naloge. | 100,00 % | Seminar project. |

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| Reference nosilca/Lecturer's references: |
| **doc. dr. Goran Vižintin**  1) VIŽINTIN, Goran, MAYER, Janez, LAJLAR, Bojan, VUKELIČ, Željko. Rock burst dependency on the type of steel arch support in the Velenje mine = Hribinski udari v odvisnosti od vrste jeklenih podpornih lokov v premogovniku Velenje. *Materiali in tehnologije*, ISSN 1580-2949. [Tiskana izd.], 2017;  2) VIŽINTIN, Goran, KOCJANČIČ, Maja, VULIĆ, Milivoj. Study of coal burst source locations in the Velenje colliery. *Energies*, ISSN 1996-1073, 2016;  3) VIŽINTIN, Goran, VESELIČ, Miran, BOMBAČ, Andrej, DERVARIČ, Evgen, LIKAR, Jakob, VUKELIČ, Željko. The development of a "drive-in" filters dewatering system in the Velenje coal mine using finite-element modelling. *Acta geotechnica Slovenica*, ISSN 1854-0171. [Tiskana izd.], 2009 ;  4) LIKAR, Jakob, DERVARIČ, Evgen, MEDVED, Milan, MAYER, Janez, VIŽINTIN, Goran. Monitoring and analyses of seismic events at the Velenje coal mine = Monitoring in analiza tresenja tal v Premogovniku Velenje. *Acta geotechnica Slovenica*, ISSN 1854-0171. [Tiskana izd.], 2008;  **izr. prof. dr. Milivoj Vulić**  1) HONUS, Stanislav, BOCKO, Peter, BOUDA, Tomáš, RISTOVIĆ, Ivica, VULIĆ, Milivoj. The effect of the number of conveyor belt carrying idlers on the failure of an impact place : a failure analysis. Engineering failure analysis, ISSN 1350-6307. [Print ed.], 2017;  2) ŠKRJANC, Žiga, VULIĆ, Milivoj. Comparison of the directional survey calculation methods applied on real well data. Measurement : journal of the International Measurement Confederation, ISSN 0263-2241. [Print ed.], 2016;  3) BORISOV, Mirko, PETROVIĆ, Vladimir, VULIĆ, Milivoj. Optimal map conic projection : a case study for the geographic territory of Serbia = Optimalna kartografska konična projekcija : analiza slučaja za geografski teritorij Srbije. Tehnički vjesnik : znanstveno-stručni časopis tehničkih fakulteta Sveučilišta u Osijeku, ISSN 1330-3651, 2015 |

# Nanomateriali Učni načrt predmeta/Course syllabus

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| Predmet: | Nanomateriali |
| Course title: | Nanomaterials |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 1. letnik |  | izbirni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 1. letnik |  | izbirni |

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| Univerzitetna koda predmeta/University course code: | 0076039 |
| Koda učne enote na članici/UL Member course code: | 784 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 45 | 30 | 0 | 0 | 0 | 75 | 5 |

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| Nosilec predmeta/Lecturer: | Marjan Marinšek |

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| Vrsta predmeta/Course type: | Izbirni / Elective |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
| Znanje osnovnih predmetov druge bolonjske stopnje s področja materialov | Previous knowledge acquired from basic courses on material science from the second cycle of Bologna programs |

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| Vsebina: | Content (Syllabus outline): |
| Predmet je razdeljen na naslednja poglavja : 1. Uvod a. kratek pregled razvoja nano-materialov s poudarkom na študiju atomističnega koncepta, od koloidne kemije do sodobne katalize, integriranih vezij in mikro-mehanskih sistemov) b. sodobni materiali (nanomateriali v pod 100 nm velikostnem področju, kvantne pike, nano-cevke in nano-žičke, tanki filmi, ostali sodobni nano-materiali) 2. Nanomateriali Kvantni efekt in efekt površine nanomaterialov, lastnosti in fenomeni (materiali, strukture in nano-površine), kemijske lastnosti nanomaterialov, površinska kemija nanomaterialov, kemijske interakcije na nano nivoju, supramolekularna kemija) 3. Priprava nanomaterialov Fizikalne in kemijske metode priprave nanomaterialov,  samourejanja gradnikov materialov, rasti klastrov, agglomeracije in rasti delcev (sinteza od zgoraj navzdol – »Top-Down« sinteza in od spodaj navzgor - »Bottom-Up« sinteza in drugi procesi) 4. Nano orodja a. Metode karakterizacije različnih tipov nanomaterialov (elektronska mikroskopija, spektroskopske in druge metode) b. inženirstvo nano-materialov (kovine in zlitine, polprevodniki, keramika in steklasti materiali, kompoziti) 5. Inženirstvo nano-materialov (kovine in zlitine, polprevodniki, keramika in steklasti materiali, kompoziti) 6. Načrtovanje nano-naprav Integracija nano-materialov v različne sisteme | The course consists of the following parts: 1. Introduction a) a short overview of advancements in the field of nano-materials with the emphasis on atomistic concept, from the early colloid chemistry to catalysis, integrated circuits and micro-mechanic systems) b) advanced materials – nano-materials (size range below 100 nm, quantum dots, nano-tubes, nano-wires, thin films and other nano-materials) 2. Nano-materials Quatum effect and surface effect of nano-materials, properties and phenomena (materials, structures and nano-surfaces), chemical properties of nano-materials, surface chemistry of nano-materials, chemical interactions on the nano-level, supra-molecular chemistry) 3. Synthesis and preparation of nano-materials Physical and chemical methods for the preparation of nano-materials, self assembly of materials components, cluster growth, agglomeration and growth of particles (»Top-Down« and »Bottom-Up« syntheses and other processes) 4. Nano-tools a) Methods for the characterization of diverse types of nano-materials (electron microscopy, spectroscopic and other methods) b) engineering of nano-materials (metals and alloys, semiconductors, ceramics, glasses, composites etc.) 5: Engineering of nano-materials (metals and alloys, semiconductors, ceramics, glasses, composites etc.) 6. Designing of nano-systems Integration of nano-materials in diverse functional systems |

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| Temeljna literatura in viri/Readings: |
| - M. Kuno, Introductory nanoscience, Garland Science, Taylor & Francis Group, LCC, New York, 2012 - M. Hosokawa, K. Nogi, M. Naito, T. Yokoyama, Nanoparticle technology handbook, Elsevier, Amsterdam, 2012 - G. L. Hornyak, J. Dutta, H. F. Tibbals, A. K. Rao, Introduction to Nanoscience, CRC Press, Taylor & Francis Group, Boca Raton, 2008 - P. Yang, The Chemistry of Nano-structured materials, World Scientific Publishing Co., River Edge, 2003 - Theodore, Louis, Nanotechnology, Basic Calculation for Engineers and Scientists, Wiley, Hoboken, 2006 - Capek, Ignác, Nanocomposite structures and dispersions: science and nanotechnology - fundamental principles and colloidal particles, Elsevier, Amsterdam, 2006 |

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| Cilji in kompetence: | Objectives and competences: |
| Cilji: V okviru predmeta se študentje spoznajo z naglim razvojem področja nano-materialov in nano-tehnologij ter njunimi perspektivami, s posebnimi in unikatnimi lastnostmi takšnih materialov, ki izvirajo iz dimenzijskih in drugih parametrov. Spoznajo se z načrtovanjem in prilagajanjem njihovih lastnosti in metodami priprave s sodobnimi fizikalnimi in kemijskimi metodami. Na osnovi lastnosti materialov se predstavi in predvidi njihovo potencialno uporabo. Želen cilj predmeta je poznavanje materialov na nano-dimenzijskem nivoju ter razumevanje razlik v strukturi in lastnostih nano-materialov v primerjavi z ostalimi materiali na mikrometrskem in večjem dimenzijskem nivoju. Specifične kompetence: Predmet seznanja študente z osnovnimi principi kemije in fizike materialov in vodi do osnovnega znanja, ki omogoča razumevanje lastnosti sodobnih nano-materialov. | Goals: In the course the students learn about the rapidly developing field on nano-materials and nanotechnologies, perspectives of this field, specific and unique properties of these materials based on the size and other parameters. They learn how to design and tailor nano-materials and their properties and how to produce them by modern physical and chemical methods. On the basis of nano-materials properties potential applications of such materials are foreseen. One of the basic goals of the course is to acquire knowledge about the materials on the nano-dimensional scale and understand the differences in the structure and properties of nano-materials as compared with the rest of materials on the micrometer and larger scale. Specific competences: The students learn about the fundamental principles of chemistry and physics of materials which gives them the basic knowledge to understand advanced nano-materials. |

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| Predvideni študijski rezultati: | Intended learning outcomes: |
| Znanje in razumevanje.  Študent bo znanja s področja klasičnih materialov razširil na nanopodročje, tj. nanomateriale, nanokompozite, nanostrukturirane materiale. Razumel bo izvor nano-efekta pri nanomaterialih. | Knowledge and understanding.  Extension of knowledge in the area of materials with knowledge specific to nanomaterials, nanocomposites and nanostructured materials. Understanding the nanoeffect. |

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| Metode poučevanja in učenja: | Learning and teaching methods: |
| Predavanja, seminarji in projektno delo. | Lectures, seminars, and project. |

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| Načini ocenjevanja: | Delež/Weight | Assessment: |
| Seminarj | 50,00 % | Seminar |
| Izpit | 50,00 % | Exam |

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| Reference nosilca/Lecturer's references: |
| MARINŠEK, Marjan, ŠALA, Martin, JANČAR, Boštjan. A study towards superior carbon nanotubes-supported Pd-based catalysts for formic acid electro-oxidation : preparation, properties and characterisation. *Journal of power sources*, ISSN 0378-7753, 2013, vol. 235, no. 1, str. 111-116  MARINŠEK, Marjan, ZUPAN, Klementina. Microstructure evaluation of sintered combustion-derived fine powder NiO-YSZ. *Ceramics international*, ISSN 0272-8842. [Print ed.], 2010, vol. 36, no. 3, str. 1075-1082   1. JAPIĆ, Dajana, PARAMO, Jorge Antonio, MARINŠEK, Marjan, STRZHEMECHNY, Yuri M., CRNJAK OREL, Zorica. Growth-morphology-luminescence correlation in ZnO-containing nanostructures synthesized in different media. *Journal of luminescence*, ISSN 0022-2313. [Print ed.], 2012, vol. 132, iss. 6, str. 1589-1596 |

# Napredne metode izrabe geotermalne energije Učni načrt predmeta/Course syllabus

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| Predmet: | Napredne metode izrabe geotermalne energije |
| Course title: | Advanced Methods of Geothermal Energy Exploitation |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Rudarstvo in geotehnologija (smer) | 1. letnik |  | izbirni |

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| Univerzitetna koda predmeta/University course code: | 0076012 |
| Koda učne enote na članici/UL Member course code: | 780 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 30 | 20 | 10 | 0 | 15 | 75 | 5 |

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| Nosilec predmeta/Lecturer: | Željko Vukelić |

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| Vrsta predmeta/Course type: | Izbirni / Elective |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
| Osnovno znanje o geologiji, dinamiki fluidov, termodinamiki in anorganski kemiji. Osnovna znanja o globinskem vrtanju in strojništvu. | Basic knowledge in geology, fluid dynamics, thermodynamics and inorganic chemistry. Basic knowledge in water and/or oil drilling and mechanical engineering. |

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| Vsebina: | Content (Syllabus outline): |
| Geološki in hidrogeološki razlogi za nastanek naravnih geotermalnih sistemov. Geotermalni sistemi kot energetski viri. Vrste geotermalnih virov, njihova uporaba in tehnologije za njihovo izkoriščanje. Trajnostnost naravnih geotermalnih virov; okoljski vplivi in socialna sprejemljivost njihove izrabe. Vodonosniki kot skladišča odvišne industrijske toplote. Raziskave in razvoj naravnih in umetnih geotermalnih virov, stanje njihove izkoriščenosti in njihov potencial v svetu in v Sloveniji. | Geological and hydro geological reasons for geothermal field’s formation. Geothermal systems as energy resources. Types of geothermal systems, their exploitation and related technologies. Sustainability of natural geothermal systems, environmental impacts and social acceptance of their exploitation. Aquifers as storages of excess industrial heat. Exploration and development of natural and artificial geothermal systems, their domestic and worldwide potentials and their existing exploitation status. |

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| Temeljna literatura in viri/Readings: |
| **Knjige/Books**  - Geothermal Energy – utilisation and technology / M.H. Dickinson, M. Fanellli (eds) / London, Earthscan, 2005 - Geothermal energy technology and current status: an overview / E. Barbier / Elsevier Scientific, 2002 - Low-Enthalpy Geothermal Resources for power Generation / D. Chandrasekharam, J. Bandschuh / Taylor & Francis, 2008 - Geothermal Power Plants / R. DiPippo / Elsevier Scientific, 2008 - Geothermal Heat Pumps – A guide for Planning & Installing / K. Ochsner / London, Earthscan, 2008 Revije/Jurnals  **Geothermal Energy Publikacije** so na voljo v knjižnicah članic UL in/ali v elektronski obliki prek spleta/ **Publications** are available at libraries of the UL members and/or in electronic version via worldwide web |

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| Cilji in kompetence: | Objectives and competences: |
| Študentje pridobijo znanja o nastanku in delovanju naravnih geotermalnih sistemov, o načinih njihovega izkoriščanja in oceni njihovih ekonomskih potencialov ter o možnostih za formiranje začasnemu shranjevanju energije namenjenih inženirskih (geo)termalnih sistemov. Cilj je usposobitev študenta za praktično delo pri raziskavah in razvoju naravnih in inženirskih geotermalnih sistemov v Sloveniji in drugod. | Students acquire knowledge on the formation and functioning of natural geothermal systems, possibilities of their exploitation, assessment of their economic potential and on the possibilities of the formation of engineered (geo) thermal system, aimed at temporary heat energy storage. Another objective is to make student capable of practical work with exploration and development of natural and engineered geothermal systems in Slovenia and elsewhere. |

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| Predvideni študijski rezultati: | Intended learning outcomes: |
| Znanje in razumevanje. | Knowledge and understanding. |

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| Metode poučevanja in učenja: | Learning and teaching methods: |
| Predavanja v predavalnici z uporabo sodobnih metod poučevanja, predstavitve z računalnikom. Praktični pouk in vaje v računalniški učilnici. Terenski ogled praktičnih primerov izkoriščanja visokoentalpijskih in nizkoentalpijskih geotermalnih virov v Sloveniji in v sosednjih državah. Vaje se izvajajo skupinsko in individualno z uporabo ustrezne programske in strojne opreme. | Traditional lecturing with the use of modern teaching methods, computer presentations. Practical work and training in the computer room. Field visits to examine practical exploitation cases of low- and high- enthalpy geothermal resources in Slovenia and neighbouring countries. Practical training will be carried on individually basis or in small groups by the use of appropriate software and hardware. |

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| Načini ocenjevanja: | Delež/Weight | Assessment: |
| Obveznost študenta je seminarsko delo, ki predstavlja njegovo samostojno raziskovalno in razvojno delo. | 100,00 % | Practical work demonstrating individual research and development work. The work has a development project character and is presented within the seminar with a discussion. Optionally, the work can be further upgraded into a scientific paper. |

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| Reference nosilca/Lecturer's references: |
| 1) VIŽINTIN, Goran, VESELIČ, Miran, BOMBAČ, Andrej, DERVARIČ, Evgen, LIKAR, Jakob, VUKELIČ, Željko. The development of a "drive-in" filters dewatering system in the Velenje coal mine using finite-element modelling. Acta geotech. Slov., 2009, vol. 6, 1, str. 50-63. [COBISS.SI-ID 948575]  2) VIŽINTIN, Goran, VUKELIČ, Željko, VULIĆ, Milivoj. Monitoring the geothermal potential of deep tertiary aquifers in north-east Slovenia using old abandoned oil and gas wells = monitoring geotermalnog potencijala dubokih tercijarnih vodonosnih horizonata u severnoistočnoj Sloveniji uz pomoč starih napuštenih bušotina nafte i gasa.  3) V: RISTOVIĆ, Ivica (ur.). Savremene tendencije u razvoju energetskog rudarstva : zbornik radova = proceedings. Beograd: Rudarsko-geolološki fakultet Univerziteta, 2008, str. 39-52. [COBISS.SI-ID 728926]  4) VIŽINTIN, Goran, STEVANOVIČ, Lidija, VUKELIČ, Željko. Development of environmental criteria for estimation of land development using GIS = Uporaba GIS-a za določitev naravnih kriterijev možnosti okoljskega razvoja. RMZ-mater. geoenviron., jun. 2008, letn. 55, št. 2, str. 237-258. [COBISS.SI-ID 808031 |

# Polimerni materiali Učni načrt predmeta/Course syllabus

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| Predmet: | Polimerni materiali |
| Course title: | Polymer Materials |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 1. letnik |  | izbirni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 1. letnik |  | izbirni |

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| Univerzitetna koda predmeta/University course code: | 0076040 |
| Koda učne enote na članici/UL Member course code: | 786 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 15 | 30 | 0 | 0 | 30 | 75 | 5 |

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| Nosilec predmeta/Lecturer: | Urška Šebenik |

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| Vrsta predmeta/Course type: | Izbirni / Elective |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
| Vpis na doktorski študij | General admission requirements |

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| Vsebina: | Content (Syllabus outline): |
| Kemijska sestava polimernih materialov. Mehanizmi polimerizacij. Vpliv procesnih pogojev polimerizacije na kemijsko sestavo in morfologijo polimerov. Vpliv kemijske sestave in morfologije polimerov in kopolimerov na njihove uporabne lastnosti. Polimerni kompoziti. Vpliv dodatkov polnil in nanodelcev na lastnosti kompozitov in nanokompozitov. Polimeri in polnila iz obnovljivih virov. Določanje kemijskih in fizikalnih lastnosti polimernih materialov in kompozitov s sodobnimi tehnikami, kot so gelska prepustnostna kromatografija, nuklearna magnetna resonanca, infrardeča spektroskopija, diferenčna dinamična kalorimetrija, termogravimetrija in druge. Fenomenološka obravnava viskoelastičnosti polimernih materialov s sodobnimi tehnikami določanja (dinamičnih) mehanskih lastnosti polimerov. Molekularni mehanizmi in matematični zapis mehanike kontinuuma. Soodvisnost frekvence in temperature. Prehodi in relaksacije v polimerih. Elastičnost polimernih mrež. Modeliranje mehanskih lastnosti kompozitnih materialov. Obravnava izbranih primerov. Recikliranje polimernih materialov. | Chemical composition of polymer materials. Polymerization mechanisms. Effects of polymerization process parameters on chemical composition and morphology of polymers. Effects of chemical composition and morphology of polymers on their applicative properties. Polymer composites. Effect of additives, fillers and nanoparticles on polymer composite properties. Polymers and composites from renewable sources. Determination of chemical and physical properties of polymer materials and composites by modern instrumental techniques, such as size exclusion chromatography, nuclear magnetic resonance, infrared spectroscopy, differential dynamic calorimetry, thermogravimetry and others. Phenomenological treatment of viscoelasticity of polymer materials. Modern techniques for measurement of (dynamic) mechanical properties of polymers. Molecular mechanisms and mathematical description of continuum mechanics. Time-temperature correspondence. Transitions and relaxations in polymers. Elasticity in rubbery networks. Modelling of mechanical properties of polymer composites. Selected cases. Recycling of polymer materials. |

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| Temeljna literatura in viri/Readings: |
| Predlagana literatura za pregled vsebinskih področij / Recommended readings for topics review:  - Rudin, The Elements of Polymer Science and Engineering, 2nd Edition, Academic Press, London, 1999, 483 pages.  - J. M. Asua, Polymer reaction engineering, Blackwell Publishing LTD, Oxford, 2007.  - Hal F. Brinson, L. Catherine Brinson, Polymer Engineering Science and Viscoelasticity. An Introduction, Springer, New York, 2008.  Literatura za seminar / Seminar readings:  Znanstvena literatura s področja polimernega inženirstva, ki se spreminja v skladu z razvojem stroke. Študenti literaturo zbirajo samostojno med študijskim procesom s pomočjo usmerjanja učitelja. / Available scientific and professional literature in the field of polymer engineering. Students will perform a literature research being supported and guided by the lecturer. |

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| Cilji in kompetence: | Objectives and competences: |
| Študenti bodo osvojili poglobljena znanja iz specifičnega področja polimernih materialov. Preučili bodo dostopno strokovno in znanstveno literaturo iz izbranega področja in jo kritično ovrednotili. Na osnovi preučene literature in zbranih dostopnih podatkov bodo sposobni načrtovati vsebino raziskovalnega dela in predvideti metode dela ter postaviti raziskovalne cilje | Deepening knowledge in specific fields of polymer material science. Studying scientific and professional literature in a specific field, critical evaluation of literature; being able to propose the content of a research project, to suggest research methods and to state its goals |

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| Predvideni študijski rezultati: | Intended learning outcomes: |
| Znanje in razumevanje: Podiplomski študenti bodo osvojili poglobljena znanja o sestavi in strukturi polimernih materialov in polimernih kompozitov ter o vplivu sestave in strukture na njihove lastnosti. Osvojili bodo znanja iz mehanike polimernih materialov na makroskopskem nivoju in relacije mehanskega obnašanja v odvisnosti od strukture materiala in mehanizma deformacije. Osvojili bodo sodobne tehnike določanja kemijskih, fizikalnih in mehanskih lastnosti polimernih materialov ter interpretacijo rezultatov. Osvojili bodo principe načrtovanja lastnosti polimernih materialov in njihovih kompozitov ter modeliranje njihovega viskoelastičnega obnašanja. | Knowledge and understanding: Students will acquire and deepen knowledge about composition and structure of polymer materials and polymer composites and about the effects of the composition and structure on their properties Mechanics of polymer materials on macroscopic level and relations of mechanical behaviour in dependence of material structure and deformation mechanism. They will acquire knowledge about modern techniques used for determination of polymer materials chemical, physical and mechanical properties with results interpretation. They will acquire principles of product design of polymer materials and polymer composites and modelling of their viscoelastic behaviour. |

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| Metode poučevanja in učenja: | Learning and teaching methods: |
| Uvodi v vsebinske sklope kot predavanja. Večina kontaktnih ur kot seminar. Obravnava izbranih primerov v diskusijskih skupinah. | Introduction to the course is given in the form of lectures. Seminars. Discussion on the selected examples within discussion groups. |

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| Načini ocenjevanja: | Delež/Weight | Assessment: |
| Seminarska naloga | 50,00 % | Seminar project |
| Ustni izpit | 50,00 % | Oral exam |

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| Reference nosilca/Lecturer's references: |
| LAPASIN, Romano, ABRAMI, M., GRASSI, Mario, **ŠEBENIK, Urška**. Rheology of Laponite-scleroglucan hydrogels. Carbohydrate polymers, Jul. 2017, vol. 168, str. 290-300, doi: 10.1016/j.carbpol.2017.03.068. [COBISS.SI-ID 1537400003]  KAJTNA, Jernej, **ŠEBENIK, Urška**. Novel acrylic/nanocellulose microsphere with improved adhesive properties. International journal of adhesion and adhesives, Apr. 2017, vol. 74, str. 100-106, doi: 10.1016/j.ijadhadh.2016.11.013. [COBISS.SI-ID 1537284547]  AMBROŽIČ, Rok, **ŠEBENIK, Urška**, KRAJNC, Matjaž. Epoxy emulsions stabilized with reactive bio-benzoxazine surfactant from epoxidized cardanol for coatings. European Polymer Journal, 2016, vol. 81, str. 138-151, doi: 10.1016/j.eurpolymj.2016.05.029. [COBISS.SI-ID 1536970435]  RUČIGAJ, Aleš, ALIČ, Branko, KRAJNC, Matjaž, **ŠEBENIK, Urška**. Curing of bisphenol A-aniline based benzoxazine using phenolic, amino and mercapto accelerators. Express polymer letters, vol. 9, no. 7, str. 647-657, doi: 10.3144/expresspolymlett.2015.60. [COBISS.SI-ID 1536286915]  RUČIGAJ, Aleš, ALIČ, Branko, KRAJNC, Matjaž, **ŠEBENIK, Urška**. Investigation of cure kinetics in a system with reactant evaporation : epoxidized soybean oil and maleic anhydride case study. European Polymer Journal, 2014 |

# Prenos toplote v metalurških tehnologijah Učni načrt predmeta/Course syllabus

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| Predmet: | Prenos toplote v metalurških tehnologijah |
| Course title: | Heat Transfer in Materials Engineering |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 1. letnik |  | izbirni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 1. letnik |  | izbirni |

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| Univerzitetna koda predmeta/University course code: | 0076041 |
| Koda učne enote na članici/UL Member course code: | 774 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 30 | 30 | 15 | 0 | 0 | 75 | 5 |

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| Nosilec predmeta/Lecturer: | Borut Kosec, doc.dr. Blaž Karpe |

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| Vrsta predmeta/Course type: | Izbirni / Elective |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
| Veljajo splošni pogoji za doktorski študij. Pogoj za vključitev v delo oziroma za opravljanje študijskih obveznosti je vpis v 1. letnik študija. | General admission requirements. Precondition for attending lectures and carrying out research work is enrolment in the 1st year of doctoral study. |

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| Vsebina: | Content (Syllabus outline): |
| Modeliranje. Pomen modeliranja procesov v inženirski praksi. Pravila in napotki. Fizikalno modeliranje. Načrtovanje in sistematika izvedbe eksperimenta. Teoretično ozadje eksperimenta. Procedura izvedbe. Priprave in instrumenti. Spremljanje protokola. Primeri: Prevod toplote. Prestop toplote. Toplotno sevanje. Inženirske aplikacije. Numerično modeliranje. Metode. Metoda končnih diferenc. Metoda končnih elementov. Metoda končnih volumnov. Metoda robnih elementov. Diskretizacija modela. Definicija lastnosti snovi. Specifikacija začetnih in robnih pogojev. Definicija obremenitev sistema. Mreženje. Konvergenčne študije. Omejitve, napake in zanesljivost. Analiza. Programska orodja. Uporabniški programski paketi (ABAQUS, FLUENT, FLOWCAST, ...). Uporaba programskih orodij in paketov. Študij, izdelava in analiza modelov: Enodimenzionalni/ ravninski problem prevoda toplote. Porazdelitve temperature v osnosimetričnem trdnem telesu. Enodimenzionalni problem toplotnega sevanja. Model temperaturnega polja v ingotu. Model temperaturnega polja v rotirajočem se valju brez in z notranjim hlajenjem. Strjevanje valjev. Toplotna obdelava valjev. Modeliranje procesov toplotnih in termokemičnih obdelav. Kontinuirno ulivanje. Ogrevanje v kontinuirni peči. Računalniško podprt izračun toplotne/materialne bilance peči. Povezava analitičnega, eksperimentalnega in numeričnega modeliranja prenosa toplote v inženirstvu materialov in metalurgiji. Raziskovalna naloga: individualno reševanje kompleksnega problema. | Modelling. Significance of numerical modelling in engineering practise. Rules and instructions. Experimental modelling. Planning and systematization of experiment realization. Realization procedure. Instrumentation, protocol. Examples: Heat transfer modes: conduction, convection, radiation. Engineering applications Numerical modelling: Methods: Finite difference method, Finite element method, Finite volume method. Material properties definition. Initial and boundary condition specification. System loading definition. The limits of stability, error and reliability. Analysis. Program tools, Program packages: (ABAQUS, FLUENT, FLOWCAST, ...) Application of program tools and packages. Study, execution and numerical modelling analyses: One-dimensional/planar conduction heat transfer problems. Temperature distribution in solid geometrical bodies. One-dimensional/planar radiation heat transfer. One-dimensional/planar convection heat transfer problems. Multi-dimensional combined heat transfer modes problems. Ingot solidification. Cylinder solidification. Temperature distribution in solid bodies during heat treatment. Heat transfer modelling in rotary cylinder with or without inside cooling. Continuous casting. Billets heating in furnace. Heat and material balance calculation in a batch type furnace. Linking analytical, experimental, and numerical modelling of heat transfer in materials engineering and metallurgy Research work: modelling of heat transfer in complex problems. |

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| Temeljna literatura in viri/Readings: |
| RAO, S.S. *The Finite Element Method in Engineering*. Oxford: Pergamon Press, 1989. KETKAR, P.S. *Numerical Thermal Analysis*. New York: ASME Press, 1999. GRANGER, R.A. *Experiments in Heat Transfer and Thermodynamics*. Cambridge: Cambridge University Press, 1994. KOSEC, B. *Finite Element Method in Heat Transfer*. Ljubljana: Univerza v Ljubljani, Naravoslovnotehniška fakulteta, 2001. DESHMUKH, Y.V. *Industrial Heating – Principles, Techniques, Materials, Applications and Design.* London: Taylor & Francis, 2005. MULLINGER, P., JENKINS B. *Industrial and Process Furnaces – Principles, Design and Operation*, Amsterdam: Butterworth – Heineman, 2008. REDDY, J.N., GARTHING, D.K. The Finite Element Method in Heat Transfer and Fluid Dynamics. London: CRC Press, 2010. RAGLAND, K.W., BRYDEN K.M. Combustion Engineering, London: CRC Press, 2011. |

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| Cilji in kompetence: | Objectives and competences: |
| Študent pri predmetu nadgradi pridobljena znanja s področja prenosa toplote in snovi, toplotne tehnike in industrijskih peči z uporabo eksperimentalnih in numeričnih modelov in simulacij. Študent se navaja na samostojno sprejemanje odločitev, povezuje in vrednoti analitične, eksperimentalno in numerično dobljene rezultate. Navaja se na samostojno in timsko delo, na projektno in raziskovalno delo, uporabo strokovne literature in sodobnih virov informacij. | Students will deepen the acquired knowledge on the field of Heat and Mass transfer, Thermal engineering, and Industrial Furnaces trough the use of experimental methods and numerical simulations. Students will practice autonomous work, taking responsibilities of decisions individually, interrelate analytical, experimental and numerical results. Acquiring team-working skills, project and research work, use of professional literature and modern information sources. |

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| Predvideni študijski rezultati: | Intended learning outcomes: |
| Povezava analitičnega, eksperimentalnega in numeričnega modeliranja prenosa toplote v inženirstvu materialov in metalurgiji. Študent pridobi sposobnosti za samostojno znanstveno-raziskovalno delo, razvoj, organizacijo in vodenje industrijskih in temeljnih raziskovalnih projektov. Pridobi znanja za samostojno izdelavo in predstavitev raziskav. | Linking analytical, experimental, and numerical modelling of heat transfer in materials engineering and metallurgy. Student will acquire skills for independent scientific research, development, organization and management of industrial projects and fundamental scientific research. |

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| Metode poučevanja in učenja: | Learning and teaching methods: |
| Predavanja, računske vaje in simulacije. Računalniške simulacije in eksperimentalno delo. Samostojno reševanje postavljenih problemov. Individualno raziskovalno in projektno delo. | Lectures. Computer calculation and numerical simulation exercises. Team and independent problem solving. Experimental work. Project work. |

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| Načini ocenjevanja: | Delež/Weight | Assessment: |
| Ustni /pisni izpiti – teorija in naloge | 60,00 % | Oral / written exams - theory and tasks |
| Reševanje odprtih nalog (problemov) | 10,00 % | Problem solving |
| izdelava, predstavitev in uspešen zagovor raziskovalne naloge | 30,00 % | Elaborating, presentation and successful defence of a project task. |

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| Reference nosilca/Lecturer's references: |
| **prof. dr. Borut Kosec, doc. dr. Blaž Karpe:**  **KOSEC B.,** KOLENKO T. Temperature field in the working rolls at continuous roll casting of aluminium strips. *Metallurgy*, 36 (1997) 4, 215-218.  **KOSEC B**., KOSEC G. Temperature field analysis on active working surface of the die-casting die. *Metall*, 57 (2003) 3, 34-136.  GOJIĆ M., LAZIĆ L**., KOSEC B.,** BIZJAK M. Application of mathematical modelling to hardenability testing of low-alloyed Mn-Mo steel. *Journal of Mechanical Engineering*, 47 (2005) 3-4, 101-108.  **KOSEC B**.. Failures of dies for die-casting of aluminium alloys. *Metallurgy*, 27 (2008) 1, 51-55.  **KARPE B., KOSEC B.**, KOLENKO T., BIZJAK M. Heat transfer analyses of continuous casting by free jet meltspinning device, *Metallurgy*, 50 (2011) 1, 13-16.  **KOSEC B., KARPE B.,** BUDAK I., LIČEN M., ĐORĐEVIĆ M., NAGODE A., KOSEC G.. Efficiency and quality of inductive heating and quenching of planetary shafts. *Metallurgy*, 51 (2012) 1, 71-74.  BIZJAK M., **KARPE B.,** JAKSA G., KOVAC J.. Surface precipitation of chromium in rapidly solidified CuCr alloys, *Applied Surface Science*, 277 (2013) 1, 83-87.  **KARPE B., KOSEC B**., NAGODE A., BIZJAK M.. The influence of Si and V on the kinetics of phase transformation and microstructure of rapidly solidified Al-Fe-Zr alloys, *Journal of mining and metallurgy. Section B, Metallurgy*, 49B (2013) 1, 83-89.  JANJIĆ G., TANASIĆ Z., **KOSEC B.**. The methodology of monitoring the implementation of a strategy in an electricity distribution enterprise. *Transactions of FAMENA*, 39 (2015) 3, 61-75.   1. IVANIĆ I., KOŽUH S., KOSEL F., **KOSEC B.,** ANŽEL I., BIZJAK M., GOJIĆ, M.. The influence of heat treatment on fracture surface morphology of the CuAlNi shape memory alloy. *Engineering failure analysis*, 77 (2017), 85-92. |

# Preoblikovanje in livarstvo - procesni inženiring Učni načrt predmeta/Course syllabus

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| Predmet: | Preoblikovanje in livarstvo - procesni inženiring |
| Course title: | Process Engineering - Forming and Casting |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 1. letnik |  | izbirni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 1. letnik |  | izbirni |

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| Univerzitetna koda predmeta/University course code: | 0076042 |
| Koda učne enote na članici/UL Member course code: | 773 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 45 | 30 | 0 | 0 | 0 | 75 | 5 |

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| Nosilec predmeta/Lecturer: | Goran Kugler, Primož Mrvar |

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| Vrsta predmeta/Course type: | Izbirni / Elective |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
| Znanje splošnih predmetov s področja materialov in metalurgije druge bolonjske stopnje. | General knowledge on materials and metallurgy acquire through master’s program. |

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| Vsebina: | Content (Syllabus outline): |
| Študent in mentor izbereta vsebine predmeta v okviru 5 KT glede na temo doktorske naloge. Teorija preoblikovanja Plastomehanika nehomogenih stanj v deformacijski coni, razvoj mikrostrukture med in po deformaciji, povezava med mikrostrukturo, plastičnostjo in lastnostmi Teorija planiranja eksperimenta Teorija podobnosti. Termomehanske simulacije metalurških stanj med in po plastični deformaciji. Eksperimentalne metode v livarstvu. Posebni preizkusi za karakterizacijo livnosti, strjevanja in preoblikovalnosti. Tribologija in termično utrujanje pri izdelavi in uporabi materialov. Teorija načrtovanja, optimiranja in kontrole kompleksnih procesnih tehnologij Uporaba modernih metod umetne inteligence, genetskega programiranja, mehke logike, za analizo in optimiranje procesnih parametrov. Gradnja informacijskih sistemov za zajemanje podatkov kot osnova za optimiranje in krmiljenje velikih industrijskih sistemov. Modeliranje strjevanja in plastične deformacije Uporaba modernih metod na osnovi fizikalne metalurgije, fizike trdne snovi in numeričnih metod. Kontrolirane plastične deformacije Plastičnost kot funkcija kemijske sestave, mikrostrukture, termomehanskih obremenitev ter termomehanske zgodovine. Plastični tok v triosnem napetostnem stanju, večosni eksperimenti. Študij nehomogenega toka v tribološkem sistemu in določevanje mejne plastičnosti. Mehanske tehnologije preoblikovana – kovanje stiskanje, valjanje, vlečenje Nadgradnja znanja o modeliranju tradicionalnih tehnologij na konkretnih primerih za industrijsko prakso (case studies). Nekonvencionalne metode preoblikovanja Preoblikovanje tankih plasti, preoblikovanje z visoko gostoto energije, hidroforming, preoblikovanje v testastem stanju, preoblikovanje kompozitnih materialov, preoblikovanje usmerjeno v načrtovanje materialov s funkcionalno porazdeljenimi lastnostmi. Posebne livarske tehnike Nadgradnja znanja o naprednih tehnologijah litja kot so nizkotlačno litje, nagibno, precizijsko, centrifugalno in večplastno litje. Uporaba modernih smernic za konstruiranje optimiranje ter računalniško generiranje livnih sistemov in geometrije ulitkov ter orodij na osnovi zahtevanih mehanskih lastnosti ter geometrijskih in obdelovalnih omejitev. Obvladovanje polnjenja livnih votlin z različnimi sistemi litja, študij turbulence in toka taline, morfologija strjevanja v realnem ulitku. Napake ulitih izdelkov ter nastanek notranjih napetosti in nekontroliranih geometrijskih sprememb Virtualni pristopi študija termičnih nehomogenosti, zaostalih notranjih napetosti, limitna stanja za nastanek geometrijskih in površinsko oblikovnih sprememb, verjetnost nastanka napak, (krčilni, plinski defekti), segregacije v ulitkih. Metode odprave napak in njihove tehnološke rešitve. Posebni uliti izdelki: Načrtovanje ulitkov s funkcionalno porazdeljenimi lastnostmi. Uporaba tehnik kot so litje v testastem stanju, izdelava sestavljenih ulitkov in tehnologije litja kompozitov. Izbrane vsebine iz strojev za litje in preoblikovanje Orodja za izdelavo materialov ter strojnih delov za specifične aplikacije: študij zdržljivosti orodij, termično utrujanje ter obraba materialov, povezava obstojnosti orodij s procesnimi parametri izdelave materialov. Izboljšanje odpornosti proti obrabi in termičnemu utrujanju z večplastnimi nanosi, nitriranjem in testiranje lastnosti površin v laboratoriju. Razvoj novih materialov za orodja in specifične strojne elemente v povezavi z proizvajalci materialov. | Student and his mentor select content of the course in the frame of 5 KT regarding to the theme of doctoral work. Theory of forming Plastomechanics of non-homogenous states in deformation zone, evolution of microstructure during and after deformation, connection between microstructure, plasticity and obtained properties. Theory of planning of experiments Theory of similarity. Thermomechanical simulation of metallurgical states during and after plastic deformation. Experimental methods in casting. Special experiments for characterization of fluidability, solidification and workability. Tribology and thermal fatigue during material production and materials application. Theory of designing, optimization and control of complex process technologies Application of modern methods of artificial intelligence, genetic programming, and fuzzy logic for analysis and optimization of process parameters. Development of information systems for acquisition of data for optimization and control of large industrial systems for material production. Modelling of solidification and plastic deformation Application of modern methods based on physical metallurgy, solid state physics and numerical methods. Controlled plastic deformation Plasticity as a function of chemical composition, microstructure, thermomechanical loadings and thermomechanical history. Material flow in three-axial stress state, multi-axial experiments. Study of non-homogenous material flow in tribological system and determination of plastic limit. Mechanical technologies of material forming (deformation) - forging, rolling, upsetting, extrusion, drawing Case studies on modelling of conventional technologies based on examples from industrial practice. Non-conventional methods of material forming (deformation) Forming of thin layers, high-energy-density forming, hydro-forming, thixoforming, forming of composite materials, thermochanical treatment of materials for production of functionally graded materials. Special casting techniques Upgrading knowledge on advanced casting technologies at low pressure die casting, high pressure die casting, tilt casting, centrifugal casting, investment casting, layered and/or composed casting. Application of modern guidelines for construction, optimization as well as computer generation of gating system and geometry of casting and tools or patterns depending on mechanical demands and geometrical and machining restricts. Mastering filling the casting cavity with different foundry techniques, study of turbulences at filling sequences, morphology of solidification in real casting. Defects in castings, generation of internal stresses and deformations of casting geometry Virtual prototype studies of thermal inhomogeneous areas in casting, rest internal stress, limit states for the formation of changes in geometry in cast part, probability of defects formation (shrinkage and gas porosity defects) in casting. Methods for removing defects with technological solutions. Special casting parts Designing castings with functional distributed properties e.g. semi solid casting, composed castings, technology of casting composites. Selected topics from casting and forming machines Tools for material production as well elements for specific application: study of tool endurance, thermal fatigue and wear of materials, connection between wear and fatigue resistances and processing parameters of material production. Improving of wear and fatigue resistances with multilayer coatings, nitriding and testing of surfaces in laboratory. Development of new materials for tools and elements in collaboration with manufacturers of materials. |

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| Temeljna literatura in viri/Readings: |
| C. Aldrich, Exploratory analysis of metallurgical process data with neural networks and related methods; Elsevier 2002, G.E. Totten, K. Funatani, L. Xie, Handbook of Metallurgical process design; 2004, P.E. Gill, W. Murray, M.H. Wright, Practical optimization; Emerald Group Pub 2001. M.F. Ashby, Materials selection and mechanical design, Pergamon press, 2005. H. Fukuyama, Y. Waseda, High temperature measurements of materials, Springer 2009. G. Gottstein, Integral materials modeling, Wiley-VCH Verlag GmbH & Co. KGaA 2007. F. Bubeck, Characterisierung und Modellierung der Gefuegeentwictlung bei der Warmumformung von Kupferewerkstoffen, TU Bergakademie Freiberg 2007. D. Siodlak, Modellierung der mechanischen Eigenschaften von niedrig legierten Mehrphasen-Stahlen mit Restaustenit unter Beruecksichtigung der dehnungsinduzierten Gefuegeanderungen, TU Bergakademie Freiberg, 2007. B. Verlinden, J. Driver, I. Samajdar, R. D. Doherty, Thermomechanical Processing of Metallic Materials, Pergamon Press 2007. C. H. Gür, J. Pan, Thermal Process Modelling of Steels, CRC Press 2009. A.B. Pollacek, Giessereikunde, Aachen 2003. P. Haasen, Physical Metallurgy, Cambridge University Press, 2003. R. Asthana, Solidification Processing of Reinforced Metals, Trans Tech Publications Ltd., 1998. Specializirane monografije za posamezna področja ter novejši članki iz znanstvenih revij. |

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| Cilji in kompetence: | Objectives and competences: |
| Študent pridobi sposobnost obravnavanja tako kompleksnega, kot tudi parcialnega vpliva tehnoloških procesnih parametrov in parametrov, ki se nanašajo na procese v materialu in vplivajo na lastnosti materialov, na zagotavljanje konstantne kakovosti, na izkoristek in na ekonomske učinke, ter na vpliv na okolje. Absolvent doktorskega študija osvoji namenska teoretska znanja in potrebo po znanstveni obravnavi metalurških tehnologij litja in preoblikovanja, obravnava lastnosti materialov na osnovi kemijske sestave, strjevanja in plastičnih deformacij, kot tudi razvoj novih materialov in tehnoloških postopkov. Usposobljen je za reševanje nalog različnih oblik tehnične prakse, kot npr. izboljšava lastnosti sodobnih materialov, razvoj novih materialov, zagotavljanje lastnosti proizvedenih materialov, orodij in uporabnosti izdelkov. Absolventi so sposobni samostojnega raziskovanja in razvoja ter predvidevanja rezultatov tehnoloških operacij v prid dviga proizvodnih in ekonomskih kazalcev apliciranih tehnologij. Z absolviranjem programa se usposobijo za kompleksno obravnavo tehnologij procesnega značaja. Ta znanja zadostujejo za samostojno raziskovalno delo pri izvedbi doktorske naloge. | Student acquires abilities to deal with complex as well as partial influences of technological process parameters and parameters referring to processes in materials which influence materials properties, quality, yield and economical efficiency and the environment. Ph.D. student acquires theoretical and practical knowledge and ability to deal with problems of casting and forming in scientific way based on chemical composition, solidification and deformation history. Student also acquires ability to develop new materials and technological procedures for solving practical technical problems with regard to the properties of produced materials, tools and applicability of products. Students are capable to carry out research autonomously and predict the results of technological operation aiming to increase production and economical indexes of the technology applied. After completing the programme students are qualified to manage complex processing technologies. |

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| Predvideni študijski rezultati: | Intended learning outcomes: |
| Znanje in razumevanje. | Knowledge and understanding. |

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| Metode poučevanja in učenja: | Learning and teaching methods: |
| Uvodna predavanja, priprava, predstavitev in zagovor seminarske naloge, projektno delo v Laboratoriju za numerična analize in Laboratoriju za preizkušanje materialov ter praktična uporaba metod pri raziskovalnem delu. | Introductory lectures, preparation and presentation of seminar work with defence, project work in the Laboratory for numerical analysis and Laboratory for materials research as well as practical application of methods during research work. |

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| Načini ocenjevanja: | Delež/Weight | Assessment: |
| Priprava, predstavitev in zagovor seminarske in projektne naloge. | 100,00 % | Preparation, presentation and defence of seminar work and projects. |

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| Reference nosilca/Lecturer's references: |
| **prof. dr. Goran Kugler**  1. G. Kugler, R. Turk: Modelling the dynamic recrystallization under multi-stage hot deformation, Acta Mater., 52 (2004), 4659-4668  2. G. Kugler, R. Turk: Study of the influence of initial microstructure topology on the kinetics of static recrystallization using a cellular automata model, Comp. Mater. Sci., 37, (2006), 284-291  3. M. Terčelj, R. Turk, G. Kugler, I. Peruš: Neural network analysis of the influence of chemical composition on surface cracking during hot rolling of AISI D2 tool steel, Comp. Mater. Sci., 42 (2008), 625-637 ;  **prof. dr. Primož Mrvar**  1. P. MRVAR, M. TRBIŽAN, J. MEDVED. Dilatation analysis of the eutectoid transformation of the as-cast spheroidal graphite cast iron. Scand. j. metall., 2002, str. 393-400.  2. I. NAGLIČ, A. SMOLEJ, M. DOBERŠEK, P. MRVAR. Influence of TiB2 particles on the effectiveness of Al-3Ti-0.15C grain refiner. Mater. charact.., 2008, vol. 59, no. 10, str. 1458-1465.  3. P. MRVAR, J. MEDVED, A. KRIŽMAN. Control of microstructure during the eutectoid transformation in the As-cast spheroidal graphite cast iron with ˝in-situ˝ dilatation analysis and quenching experiments. Steel research international, 2006, vol. 77, no. 5, str. 353-361. |

# Raziskovalno delo - 1. letnik Učni načrt predmeta/Course syllabus

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| Predmet: | Raziskovalno delo - 1. letnik |
| Course title: | Research Work |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 1. letnik |  | obvezni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 1. letnik |  | obvezni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Rudarstvo in geotehnologija (smer) | 1. letnik |  | obvezni |

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| Univerzitetna koda predmeta/University course code: | 0076015 |
| Koda učne enote na članici/UL Member course code: | 800 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 0 | 0 | 0 | 0 | 0 | 600 | 20 |

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| Nosilec predmeta/Lecturer: |  |

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| Vrsta predmeta/Course type: | Obvezni / Compulsory |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
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| Vsebina: | Content (Syllabus outline): |
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| Temeljna literatura in viri/Readings: |
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| Cilji in kompetence: | Objectives and competences: |
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| Predvideni študijski rezultati: | Intended learning outcomes: |
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| Metode poučevanja in učenja: | Learning and teaching methods: |
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| Načini ocenjevanja: | Delež/Weight | Assessment: |
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| Reference nosilca/Lecturer's references: |
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# Raziskovalno delo - 2. letnik Učni načrt predmeta/Course syllabus

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| Predmet: | Raziskovalno delo - 2. letnik |
| Course title: | Research Work |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 2. letnik |  | obvezni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 2. letnik |  | obvezni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Rudarstvo in geotehnologija (smer) | 2. letnik |  | obvezni |

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| Univerzitetna koda predmeta/University course code: | 0076019 |
| Koda učne enote na članici/UL Member course code: | 801 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 0 | 0 | 0 | 0 | 0 | 1350 | 45 |

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| Nosilec predmeta/Lecturer: |  |

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| Vrsta predmeta/Course type: | Obvezni / Compulsory |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
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| Vsebina: | Content (Syllabus outline): |
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| Temeljna literatura in viri/Readings: |
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| Cilji in kompetence: | Objectives and competences: |
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| Predvideni študijski rezultati: | Intended learning outcomes: |
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| Metode poučevanja in učenja: | Learning and teaching methods: |
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| Načini ocenjevanja: | Delež/Weight | Assessment: |
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| Reference nosilca/Lecturer's references: |
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# Raziskovalno delo - 3. letnik Učni načrt predmeta/Course syllabus

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| Predmet: | Raziskovalno delo - 3. letnik |
| Course title: | Research Work |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 3. letnik |  | obvezni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 3. letnik |  | obvezni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Rudarstvo in geotehnologija (smer) | 3. letnik |  | obvezni |

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| Univerzitetna koda predmeta/University course code: | 0144354 |
| Koda učne enote na članici/UL Member course code: | 802 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 0 | 0 | 0 | 0 | 0 | 1800 | 60 |

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| Nosilec predmeta/Lecturer: |  |

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| Vrsta predmeta/Course type: | Obvezni / Compulsory |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
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| Vsebina: | Content (Syllabus outline): |
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| Temeljna literatura in viri/Readings: |
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| Cilji in kompetence: | Objectives and competences: |
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| Predvideni študijski rezultati: | Intended learning outcomes: |
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| Metode poučevanja in učenja: | Learning and teaching methods: |
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| Načini ocenjevanja: | Delež/Weight | Assessment: |
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| Reference nosilca/Lecturer's references: |
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# Raziskovalno delo - 4. letnik Učni načrt predmeta/Course syllabus

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| Predmet: | Raziskovalno delo - 4. letnik |
| Course title: | Research Work |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 4. letnik |  | obvezni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 4. letnik |  | obvezni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Rudarstvo in geotehnologija (smer) | 4. letnik |  | obvezni |

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| Univerzitetna koda predmeta/University course code: | 0144356 |
| Koda učne enote na članici/UL Member course code: | 802 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 0 | 0 | 0 | 0 | 0 | 1650 | 55 |

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| Vrsta predmeta/Course type: | Obvezni / Compulsory |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
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| Cilji in kompetence: | Objectives and competences: |
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| Predvideni študijski rezultati: | Intended learning outcomes: |
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| Metode poučevanja in učenja: | Learning and teaching methods: |
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| Načini ocenjevanja: | Delež/Weight | Assessment: |
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| Reference nosilca/Lecturer's references: |
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# Sodobne tehnologije gradnje in numerično modeliranje podzemnih objektov Učni načrt predmeta/Course syllabus

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| Predmet: | Sodobne tehnologije gradnje in numerično modeliranje podzemnih objektov |
| Course title: | Modern Construction Technologies and Numeric Modelling of Underground Structures |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Rudarstvo in geotehnologija (smer) | 1. letnik |  | izbirni |

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| Univerzitetna koda predmeta/University course code: | 0076013 |
| Koda učne enote na članici/UL Member course code: | 776 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 30 | 15 | 15 | 0 | 15 | 75 | 5 |

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| Nosilec predmeta/Lecturer: | Vojkan Jovičić |

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| Vrsta predmeta/Course type: | Izbirni / Elective |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
| Za izbiro predmeta je pogoj znanje iz vsebin predmetov Mehanika tal, Mehanika kamnin, Podzemni objekti z magistrskega študijskega programa Geotehnologija in rudarstvo oz. osvojena primerljiva znanja. | Completed courses from master's programme in Geotechnology and Mining: Soil mechanics, Rock mechanics, Underground structures, or other comparable courses. |

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| Vsebina: | Content (Syllabus outline): |
| Vsebinska osnova predmeta je zasnovana na pridobitvi znanja z upoštevanjem specifičnosti in kompleksnosti gradnje podzemnega objekta. V naslednjih sklopih so sistematsko podana vsebine: - Poglobljene analize razumevanja sodobnih metod gradnje podzemnih objektov z upoštevanjem metod opazovanj in njihova praktična uporaba - Načrtovanje ciljnih raziskav in opazovanj hribinskih območij z uporabo kritične presoje razpoložljivih metod raziskovanja s prednostmi in omejitvami - Analiza laboratorijskih metod raziskovanja hribin s kritično presojo uporabnosti rezultatov v okviru določanja projektnih parametrov - Inženirska presoja klasifikacij hribin s poudarkom na določanju geomehanskih parametrov hribinskih gmot in širših hribinskih območij - Geotehnično načrtovanje sistema hribina - konstrukcija z uporabo rezultatov geomehanskih raziskav - Analiza in kritična presoja geoloških in tehnoloških tveganj pri uporabi cikličnih metod gradnje podzemnih objektov s poudarkom na Novi avstrijski metodi gradnje predorov – NATM - Ekonomika in pogodbeni odnosi med naročnikom in izvajalcem pri gradnji podzemnih objektov ob upoštevanju principov NATM - Analiza in kritična presoja geoloških in tehnoloških tveganj pri uporabi strojnih metod gradnje podzemnih objektov s poudarkom na TBM - Ekonomika in pogodbeni odnosi med naročnikom in izvajalcem pri gradnji podzemnih objektov z uporabo TBM - Poglobljena analiza konstrukcijskih faz gradnje in numerična simulacija z implementacijo ustreznih konstitutivnih modelov hribin pri cikličnem kot tudi strojno mehanskem načinu izkopa podzemnih prostorov - Pregled in presoja ključnih načinov vodenja podzemnih gradenj ob upoštevanju principov ekonomičnosti in gospodarnosti ob zagotovljenih predpisanih varnostnih pogojih za področje podzemnih del Načini načrtovanja in implementacije varnostnih ukrepov z upoštevanjem zakonodaje s področja varnosti in zdravja pri delu. | The Crouse has been designed in view of the specifics and complexity of underground construction. It includes the following topics: - Detailed and accurate analyses for understanding modern construction methods of underground structures, considering methods of observation and their practical applications. - Planning target-oriented research and observations of rock sites by using critical assessment of the research methods, their advantages and limitations. - Analysis of laboratory methods of rock research by critical evaluation of the results in terms of defining project parameters. - Engineering assessment of the classification of rocks with emphasis on determining geomechanical parameters of the rock mass and the broader construction site. - Geotechnical design of the system rock – construction by using the results of geomechanical analyses. - Analysis and critical evaluation of geological and technological risks in using cyclic methods of the construction of underground structures with emphasis on the New Austrian Tunnelling Method – NATM. - Economic aspects and contractual relationships between the contractor and the developer of underground structures by considering the principles of NATM. - Analysis and critical evaluation of geological and technological risks in using machine methods in underground construction with emphasis on TBM. - Economic aspects and contractual relationships between the client and contractor of underground structures by considering the principles of TBM. - Deep understanding analysis of construction phases and numerical simulation with implementation of suitable constitutive models of rocks in conventional cyclic and mechanical methods of underground excavations. - Survey, observation and assessment of key methods in conducting underground constructions with special consideration to the economic principles and regulations for safe work in underground environments. Methods of planning and implementation of safety measures with regard to the legislation in the field of health and safety at work. |

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| Temeljna literatura in viri/Readings: |
| 1) W. Wittke, Stability Analysis for Tunnels, VGE Verlg Glϋckauf GmbH, Essen 2000 2) W. Wittke, B. Pierau, C. Erichsen, Statik und Konstruktion der Spritzbetonbauweise, VGE Verlag Glϋckauf GmbH, Essen 2002 3) W. Wttke et.al., Statik und Konstruktion maschineller Tunnelvortriebe, VGE Verlag Glϋckauf GmbH, Essen 2002 4) G. Beer, Numerical Simulation in Tunneling, Springer-Verlag Wien, 2003. |

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| Cilji in kompetence: | Objectives and competences: |
| Doktorand je na osnovi svojega predhodnega izobraževanja usposobljen, da samostojno rešuje naloge s področja geomehanike in podzemnih gradenj z uporabo numeričnih modelov za potrebe načrtovanja in analiziranja tovrstnih konstrukcij. Posebna znanja s področja inženirske geologije in hidrologije mora doktorand znati uporabiti pri zasnovah geometričnih parametrov podzemnega prostora ob upoštevanju posebnosti hribinskih območij ter temu primerno predvideti sodobno tehnološko osnovo načina gradnje podzemnega objekta. Za kompleksno dojemanje gradnje podzemnega objekta mora doktorand poznati tudi merske metode geometrične spremljave, geološko geotehnično vrednotenje opazovanih in merjenih parametrov strukturnih, mehanskih in kemičnih lastnosti zemljin in kamnin ter jih znati inženirsko interpretirati. | Based on previously acquired knowledge the candidate is able to solve tasks related to geomechanics and underground construction, and by using numerical models to design and analyse such constructions; is able to apply special knowledge in engineering geology and hydrology in setting geometric parameters for underground space construction while considering rock characteristics, and to plan modern technological approaches for the construction of underground structures; is able to apply measurement methods for geometric analyses, carry out geological and geotechnical assessment of the observed and measured parameters of structural, mechanical and chemical properties of soils and rocks and to interpret them in terms of engineering. |

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| Predvideni študijski rezultati: | Intended learning outcomes: |
| Znanje in razumevanje: Razumevanje vsebin in napredek pri predmetu zahteva poglobljeno znanje osnovnih strokovnih predmetov kot so mehanika, inženirska geologija, mehanika kamnin, mehanika tal, vključno z drugimi inženirskimi predmeti s področja materialov. Napredovanje v znanju pomembnega področja podzemnih gradenj omogoča sinteza znanj več predmetov iz predhodnih semestrov. Posebej se za ta predmet zahteva študentovo interdisciplinarno znanje in organiziranost ter sistematični način dela. To je povezano s prevzemanjem inženirske odgovornosti pri znanstvenem analiziranju ter načrtovanju ali izvajanju zahtevnih podzemnih objektov. | Knowledge and understanding: Understanding the content and progress of the present course requires detailed knowledge of basic professional courses such as mechanics, engineering geology, rock and soil mechanics, including other fields of engineering materials. Advancement in knowledge of key areas of underground constructions topic allows the synthesis of several subtopics of knowledge from previous semesters. Especially for this course requires the student's interdisciplinary knowledge, organizational and systematic approach to study. This is linked with the engineering responsibilities in the scientific analysis and planning or implementation of complex underground structures. |

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| Metode poučevanja in učenja: | Learning and teaching methods: |
| Konzultacije, strokovna literatura, študij primerov dobre prakse, numerično modeliranje podzemnih gradenj na konkretnih primerih. | Consultations, using professional literature, studies of examples of good practice, numerical modelling of underground constructions on real examples. |

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| Načini ocenjevanja: | Delež/Weight | Assessment: |
| Izdelava in predstavitev seminarske naloge | 100,00 % | Preparation and presentation of seminar work |

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| Reference nosilca/Lecturer's references: |
| 1. JOVIČIĆ, Vojkan, ŠUŠTERŠIČ, Jakob, VUKELIČ, Željko. The application of fibre reinforced shotcrete as primary support for a tunnel in flysch. Tunn. undergr. space technol.. [Print ed.], 2009, vol. 24, no. 6, str. 723-730. [COBISS.SI-ID 946015] 2. JOVIČIĆ, Vojkan, ŠUŠTERŠIČ, Jakob. Use of fibre-reinforced shotcrete for primary lining in the Dekani tunnel. Quark (Engl. ed.). [English ed.], Summer 2008, str. 112-117, ilustr. [COBISS.SI-ID 29848325] 3. VUKADIN, Vladimir, LIKAR, Jakob, JOVIČIĆ, Vojkan. Development of a conceptual material model for structured materials -S\_BRICK. Acta geotech. Slov., 2005, letn. 2, [št.] 1, str. 32-43. [COBISS.SI-ID 1050339] 4. LIKAR, Jakob, JOVIČIĆ, Vojkan. The causes of excessive settlement above Trojane Tunnel and remedial measures. Tunn. undergr. space technol.. [Print ed.], 2004, vol. 19, no. 4/5, str. 386-387. http://authors.elsevier.com/sd/article/S0886779804000847. [COBISS.SI-ID 932835] 5. JOVIČIĆ, Vojkan. Analyses of convergence displacements of Trojane tunnel at west portals = Analiza konvergentnih pomikov v predoru Trojane na območju zahodnega portala. RMZ-mater. geoenviron., 2002, let. 49, št. 1, str. 37-49. [COBISS.SI-ID 646627] 6. JOVIČIĆ, Vojkan. Cut & cover construction in overconsolidated clays = Načrtovanje pokritega vkopa v prekonsolidiranih glinah. RMZ-mater. geoenviron., 2001, vol. 48, no. 2, str. 86-98. [COBISS.SI-ID 265055] 7. JOVIČIĆ, Vojkan, COOP, M. R. The measurement of stiffness anisotropy in clays with bender element tests in the triaxial apparatus. ASTM geotech. test. j., March 1998, vol. 21, no. 1, str. 3-10. [COBISS.SI-ID 452579] 8. JOVIČIĆ, Vojkan, COOP, M. R. Stiffness of coarse-grained soils at small strains. Geotechnique. [Print ed.], August 1997, vol. 47, no. 3, str. 545-561. [COBISS.SI-ID 453091] 9. JOVIČIĆ, Vojkan, COOP, M. R., SIMIĆ, M. Objective criteria for determining G max from bender element tests. Geotechnique. [Print ed.], June 1996, vol. 46, no. 2, str. 357-362. [COBISS.SI-ID 453347] 10. Selected publications at international conferences: 11. JOVIČIĆ, Vojkan, LOGAR, Janko. Design of a deep tunnel in a layer of a normally consolidated clay = Dimensionnement d'un tunnel profond dans l'argile normalement consolidée. V: HAMZA, Mamdouh (ur.). Proceedings of the 17th International Conference on Soil Mechanics and Geotechnical Engineering : 5-9 October 2009, Alexandria, Egypt : The Academia and Practice of Geotechnical Engineering : 5-9 Octobre 2009, Alexandrie, Egypte : Le monde universitaire et la pratique en geotechnique. Amsterdam [etc.]: IOS Press, cop. 2009, vol. 2, str. 1838-1841, ilustr. [COBISS.SI-ID 4766817] 12. JOVIČIĆ, Vojkan. Case histories of three motorway tunnels built in Montenegro = Zgodovinski pregled treh avtocestnih predorov zgrajenih v Črni Gori. V: KOSTIOV, Leon (ur.), LIKAR, Jakob (ur.). 8. mednarodno posvetovanje o gradnji predorov in podzemnih prostorov, 15.-17. november 2006, Ljubljana, Slovenija = 8th International Conference on Tunnel Construction and Underground Structures, 15-17th November 2006, Ljubljana, Slovenija. Zbornik referatov. Ljubljana: Naravoslovno tehniška fakulteta, Oddelek za geotehnologijo in rudarstvo, 2007, str. 237-244. [COBISS.SI-ID 1246179] 13. JOVIČIĆ, Vojkan. Examples of active design in tunnelling. V: LOGAR, Janko (ur.), GABERC, Ana Marija (ur.), MAJES, Bojan (ur.). Active geotechnical design in infrastructure development : proceedings of the XIIIth Danube-European Conference on Geotechnical Engineering, 29-31 May 2006, Ljubljana, Slovenia : Tagungsband der XIII. Donau-Europäische Konferenz für Geotechnik, 29.-31. Mai 2006, Ljubljana, Slowenien. Ljubljana: Slovensko geotehniško društvo: = Slovenian Geotechnical Society, 2006, str. 439-444. [COBISS.SI-ID 1179875] |

# Soglasje k temi doktorske disertacije Učni načrt predmeta/Course syllabus

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| Predmet: | Soglasje k temi doktorske disertacije |
| Course title: | Approved Topic of PhD Thesis |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 2. letnik |  | obvezni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 2. letnik |  | obvezni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Rudarstvo in geotehnologija (smer) | 2. letnik |  | obvezni |

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| Univerzitetna koda predmeta/University course code: | 0076020 |
| Koda učne enote na članici/UL Member course code: | 804 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 0 | 0 | 0 | 0 | 0 | 150 | 5 |

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| Nosilec predmeta/Lecturer: |  |

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| Vrsta predmeta/Course type: | Obvezni / Compulsory |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
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| Vsebina: | Content (Syllabus outline): |
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| Temeljna literatura in viri/Readings: |
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| Cilji in kompetence: | Objectives and competences: |
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| Predvideni študijski rezultati: | Intended learning outcomes: |
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| Metode poučevanja in učenja: | Learning and teaching methods: |
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| Načini ocenjevanja: | Delež/Weight | Assessment: |
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| Reference nosilca/Lecturer's references: |
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# Spektroskopija materialov Učni načrt predmeta/Course syllabus

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| Predmet: | Spektroskopija materialov |
| Course title: | Spectroscopy of Materials |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 1. letnik |  | izbirni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 1. letnik |  | izbirni |

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| Univerzitetna koda predmeta/University course code: | 0076044 |
| Koda učne enote na članici/UL Member course code: | 763 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 45 | 30 | 0 | 0 | 0 | 75 | 5 |

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| Nosilec predmeta/Lecturer: | Janez Dolinšek |

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| Vrsta predmeta/Course type: | Izbirni / Elective |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
| Vpis v letnik. | General admission requirements. |

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| Vsebina: | Content (Syllabus outline): |
| Jedrska magnetna resonanca in elektronska paramagnetna resonanca: Magnetni momenti atomov, jeder in elektronov, spinska magnetizacija in Zeemanski razcep, resonančni eksperiment in aparatura, spinska relaksacija, Fourierova transformacija in absorpcijski spekter, kemijski premik, električna kvadrupolna interakcija, vrtenje pod magičnim kotom, Knightov premik v kovinah, dvodimenzionalna NMR spektroskopija, slikanje z magnetno resonanco, elektronska paramagnetna resonanca (EPR), zvezni in pulzni EPR. II. Spektroskopija z gama žarki: Mössbauerjeva spektroskopija, radiacijski izvori in detektorji, perturbirana kotna korelacija. III. Spektroskopija s pozitroni in mioni: Pozitronska anihilacijska spektroskopija, mionska spinska rotacija. IV. Nevtronsko sipanje: Nevtronski izvori, termični nevtroni, hladni in vroči nevtroni, nevtronski spektrometer in detektor, nevtronsko sipanje, sipalni presek, koherentno in nekoherentno sipanje, neelastično nevtronsko sipanje. V. Spektroskopija z atomi in ioni: Instrumentacija za atomsko in ionsko spektroskopijo, izvori atomskih žarkov, pospeševalniki, analizator in detektor, energijske izgube in vdor žarkov v trdno snov, spektrometrija povratno sipanih delcev, Rutherfordovo povratno sipanje, sekundarna ionska masna spektroskopija. VI. Magnetizem: SQUID magnetometer, detekcija z gradiometrom. VII. Mertive transportnih pojavov v snovi: Električna upornost, magnetoupornost, termoelektrična napetost, toplotna prevodnost, toplotna kapaciteta. | I. NMR and EPR II. Gamma spectroscopy III. Positron and muon spectroscopy IV. Neutron scattering V. Spectroscopy with atoms and ions VI. Magnetic measurements VII. Transport measurements |

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| Temeljna literatura in viri/Readings: |
| Solid State Spectroscopy; H. Kuzmany (Springer, Berlin, Heidelberg, 1998) |

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| Cilji in kompetence: | Objectives and competences: |
| Spoznavanje spektroskopskih eksperimentalnih metod v raziskavah materialov. | Acquiring knowledge on spectroscopic experimental methods in materials science. |

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| Predvideni študijski rezultati: | Intended learning outcomes: |
| Znanje in razumevanje modernih spektroskopskih metod za raziskave in karakterizacijo materialov. | Knowledge and understanding of modern spectroscopic methods for the research and characterization of materials. |

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| Metode poučevanja in učenja: | Learning and teaching methods: |
| Predavanja, vaje in projekti, domače naloge in konzultacije. | Lectures, exercises, homework, consultations. |

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| Načini ocenjevanja: | Delež/Weight | Assessment: |
| Izpit pisni ali/in ustni. | 100,00 % | Written and/or oral exam. |

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| Reference nosilca/Lecturer's references: |
| 1. DOLINŠEK, Janez, VRTNIK, Stanislav, KLANJŠEK, Martin, JAGLIČIĆ, Zvonko, SMONTARA, Ana, SMILJANIĆ, Igor, BILUŠIĆ, Ante, YOKOYAMA, Y., INOUE, Akihisa, LANDAURO, C. V. Intrinsic electrical, magnetic, and thermal properties of single-crystalline Al[sub](64)Cu[sub](23)Fe[sub](13) icosahedral quasicrystal: experimental and modeling. Phys. rev., B, Condens. matter mater. phys., 2007, vol. 76, no. 5, str. 054201-1-054201-9. 2. DOLINŠEK, Janez, SLANOVEC, Jernej, JAGLIČIĆ, Zvonko, HEGGEN, M., BALANETSKYY, S., FEUERBACHER, M., URBAN, K. Broken ergodicity, memory effect, and rejuvenation in Taylor-phase and decagonal Al[sub]3(Mn, Pd, Fe) complex intermetallics. Phys. rev., B, Condens. matter mater. phys., 2008, vol. 77, no. 6, str. 064430-1-064430-18. 3. DOLINŠEK, Janez, KOMELJ, Matej, JEGLIČ, Peter, VRTNIK, Stanislav, STANIĆ, Denis, POPČEVIĆ, P., IVKOV, Jovica, SMONTARA, Ana, JAGLIČIĆ, Zvonko, GILLE, Peter, GRIN, Yuri. Anisotropic magnetic and transport properties of orthorhombic Al[sub](13)Co[sub]4. Phys. rev., B, Condens. matter mater. phys., 2009, vol. 79, no. 18, str. 184201-184201-12. 4. PAPAVASSILIOU, George C., DOLINŠEK, Janez. Orbital domain state and finite size scaling in ferromagnetic insulating manganites. Phys. rev. lett., 2003, vol. 91, str. 147205-1-147205-4. 5. DOLINŠEK, Janez, MCGUINESS, Paul J., KLANJŠEK, Martin, SMILJANIĆ, Igor, SMONTARA, Ana, ZIJLSTRA, E. S., BOSE, S. K., FISHER, I. R., KRAMER, M. J., CANFIELD, P. C. Extrinsic origin of the insulating behavior of polygrain icosahedral Al-Pd-Re quasicrystals. Phys. rev., B, Condens. matter mater. phys., 2006, vol. 74, str. 134201-1-134201-7. 6. DOLINŠEK, Janez, VRTNIK, Stanislav, KLANJŠEK, Martin, JAGLIČIĆ, Zvonko, SMONTARA, Ana, SMILJANIĆ, Igor, BILUŠIĆ, Ante, YOKOYAMA, Y., INOUE, Akihisa, LANDAURO, C. V. Intrinsic electrical, magnetic, and thermal properties of single-crystalline Al[sub](64)Cu[sub](23)Fe[sub](13) icosahedral quasicrystal: experimental and modeling. Phys. rev., B, Condens. matter mater. phys., 2007, vol. 76, no. 5, str. 054201-1-054201-9. |

# Strjevanje kovinskih talin Učni načrt predmeta/Course syllabus

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| Predmet: | Strjevanje kovinskih talin |
| Course title: | Solidification Processes of Metallic Materials |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 1. letnik |  | izbirni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 1. letnik |  | izbirni |

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| Univerzitetna koda predmeta/University course code: | 0076045 |
| Koda učne enote na članici/UL Member course code: | 771 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 45 | 30 | 0 | 0 | 0 | 75 | 5 |

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| Nosilec predmeta/Lecturer: | Primož Mrvar |

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| Vrsta predmeta/Course type: | Izbirni / Elective |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
| Opravljen magistrski študij ter poznavanje kemije, termodinamike, fizikalne metalurgije in osnov livarstva. | Completed master’s degree with adequate knowledge of chemistry, thermodynamics, physical metallurgy and fundamentals of foundry. |

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| Vsebina: | Content (Syllabus outline): |
| • Termodinamski pogoji procesa strjevanja: podhlajenje • Makroskopski in mikroskopski pristop k strjevanju, nastanek mikrostrukture: vpliv prenosa toplote na proces nukleacije in kristalizacije • Rast kristalnih zrn iz taline: nestabilnost strjevalne fronte • Peritektsko in monotektstko strjevanje: model rasti celic in dendritov, stebričasto in osnosimetrično strjevanje • Eutektsko strjevanje: facetirano in nefacetirana rast, sklopljena in nesklopljena rast • Neravnotežno strjevanje: makro in mikrosegregacije, modeli segregacije v ingotih in kontinuirno ulitih blokih, strukturna področja v realnih ulitkih v odvisnosti od pogojev strjevanja • Uporaba teorije strjevanja v industrijski praksi: obdelava taline, teoretični in praktični učinki modificiranja in/ali ceplenja ter padanje učinka cepljenja in modifikacije s časom zadrževanja taline • Napovedovanje lite mikrostrukture v odvisnosti od parametrov procesa: modificiranje in udrobnjevanje pri posameznih zlitinah (železove, aluminijeve, magnezijeve zlitine,…)  • Nadzor kakovosti taline in strjevanja: računalniško podprte “in situ” analize za napovedovanje morfologije strjevanja in rozvoja lite makro in mikrostrukture Defekti v ulitkih pri strjevalnih procesih. | • Thermodynamic condition of solidification process: undercooling requirement • Macroscopic and microscopic aspect of solidification and formation of microstructure: effect of material and heat transfer on nucleation and crystallization process • Crystal growth from the melt: instability of solidification front • Peritectic and monotectic solidification (2): cellular and dendritic growth models, columnar and equiaexed solidification • Eutectics solidification (3): faceted-nonfaceted eutectics growth models, coupled cone competitive growth • Nonequlibrium solidification (4); macro and micro segregation, segregation patterns in ingots and continuous casting, structural cones in real castings • Application of solidification theories to industrial processes (4): melt treatment, theoretical and practical aspects of modification, inoculation and fading effects • Prediction of as-cast microstructure as function of process parameters (4): modification and grain refinement of cast irons, Al-Si alloys, etc. • Melt quality and solidification control (4): computer-aided “in situ” analysis for prediction of solidification model and development of as-cast microstructures Solidification defects in castings (4) |

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| Temeljna literatura in viri/Readings: |
| 1. W. Kurz, D.J. Fisher, “Fundamentals of Solidification” Trans Tech Publication, Aedermannsdorf, Switzerland, 1986.  2. J.E.Gruzleski, “Microstructure Development during Metalcasting”, American Foundrymen’s Society INC., Des Plines, Ilinois, USA, 2000 3. R. Elliot, “Eutectic Solidification Processing, Crystalline and Glass Alloy”, Butterworths, London, 1983.  4. D.A. Porter, K. E. Easterling, “Phase Transformation in Metals and Alloys”, Chapman Hall, London, 1996.  5. Snil Kumar Sinha, “Phisical Metalurgy Handbook”, McGraw-Hill Companies Inc., USA, 2003.  6. Doru Michael Stefanescu, “Science and Engineering of Casting Solidification”, Kluwer Academic/Plenum Publishers, New York, 2002.  7. Cambell, J.: Castings, OBE, Feng, Butterworth Heinemann Ltd, 1991.  8. Asthana R. Solidification Processing of Reinforced Metals, Trans Tech Publications Ltd.,1998  9. Cambell, J.: Complete Casting Handbook 2nd Edition, Butterworth Heinemann Ltd, 2015.,  10. Specialirizirane monografije za posamezna področja ter novejši članki iz znanstvenih revij. |

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| Cilji in kompetence: | Objectives and competences: |
| Študent osvoji teorije strjevanja kovin in zlitin, s poudarkom na strjevalnih parametrih in morfologiji strjevanja, ki vplivajo na izoblikovanje mikro in makrostrukture v litem stanju. Posebni poudarek je na sekvenci strjevanja, ki poteka v odvisnosti od tehnike strjevanja in robnih pogojev. S pomočjo “in situ” metod se nauči zasledovati posamezne sekvence s področja strjevanja in transformacij v trdnem, ter jih kvantitativno poveže z nastalo mikrostrukturo, pri čemer opredeli morfologijo strjevanja. Seznani se z načrtovanjem mikro in makro strukture. Eksperimentalno in modelsko opredeli strjevanje za posamezni ulitek. | Acquiring theoretical bases of solidification of metals and alloys with emphasis on correlation between solidification parameters and development of as-cast macro and microstructure, metal casting properties. Solidification process, which is unique for each solidification technique, will be emphasized. Students acquire knowledge through ˝in situ˝ methods which are used for following the solidification sequences and also solid state transformations. These can be quantitatively linked to a formed microstructure where solidification morphology is determined. Students learn how to plan and predict micro and macro-structure for each solidification technique and using a model defines the solidification of castings. |

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| Predvideni študijski rezultati: | Intended learning outcomes: |
| Znanje in razumevanje: Strjevanlnih procesov na nano, mikro in makro nivoju, rekonstruira in prepozna morfološke tipe pri strjevanju, prepozna in opiše neravnotežne tipe strjevanja, razume nastanek lite mikrostrukture v odvisnosti od parametrov procesa, Razume in povezuje rezultate kontrolnih metod, ki se uporabljajo v livarstvu, celovito razume nastanek napak in jih identificira ter prepoznava. | Knowledge and understanding: Solidification process on nano, micro and macro level, reconstruct and identified the morphological types at the solidification process, recognize and describe the un-equilibrium types of solidification, understands the as cast microstructure formation dependence of parameters of process, Understand and connect the results of controlling methods and understand the formation of defects. |

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| Metode poučevanja in učenja: | Learning and teaching methods: |
| Uvodna predavanja, priprava, predstavitev in zagovor seminarske naloge, projektno delo v Laboratoriju za simulacijo livarskih procesov, Livarskem laboratoriju in Talilnem laboratoriju. | Introductory courses, preparation and presentation of seminar, project work in the Laboratory for simulation of foundry processes, and in Casting and Melting laboratories |

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| Načini ocenjevanja: | Delež/Weight | Assessment: |
| Priprava, predstavitev in zagovor seminarske in projektne naloge. | 100,00 % | Presentation of seminar and project work |

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| Reference nosilca/Lecturer's references: |
| 1. MRVAR, Primož, TRBIŽAN, Milan, MEDVED, Jože. Dilatation analysis of the eutectoid transformation of the as-cast spheroidal graphite cast iron. Scand. j. metall., 2002, str. 393-400.  2. MRVAR, Primož, MEDVED, Jože, KRIŽMAN, Alojz. Control of microstructure during the eutectoid transformation in the As-cast spheroidal graphite cast iron with ˝in-situ˝ dilatation analysis and quenching experiments. Steel research international, 2006, vol. 77, no. 5, str. 353-361.  3. PETRIČ, Mitja, MEDVED, Jože, MRVAR, Primož. Effect of grain refinement, modification and cooling rate on the microstructure of alloy 239 and 226. Giessereiforschung, 2008, vol. 60, no. 2, str. 26-37.  4. NAGLIČ, Iztok, SMOLEJ, Anton, DOBERŠEK, Mirko, MRVAR, Primož. Influence of TiB2 particles on the effectievness of Al-3Ti-0.15C grain refiner. Mater. charact.. [Print ed.], 2008, vol. 59, no. 10, str. 1458-1465.  5. PETRIČ, Mitja, MEDVED, Jože, DOLENC, Matej, MRVAR, Primož. Solidification characteristics of Al-Si-Mg-Fe/Al2O3 metal matrix composites. Journal of thermal analysis and calorimetry, ISSN 1388-6150. [Print ed.], 2015, vol.122, no.2, str. 563-570. |

# Strokovno izpopolnjevanje Učni načrt predmeta/Course syllabus

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| Predmet: | Strokovno izpopolnjevanje |
| Course title: | Professional Training |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 1. letnik |  | obvezni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 1. letnik |  | obvezni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Rudarstvo in geotehnologija (smer) | 1. letnik |  | obvezni |

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| Univerzitetna koda predmeta/University course code: | 0076016 |
| Koda učne enote na članici/UL Member course code: | 809 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 0 | 0 | 0 | 0 | 75 | 75 | 5 |

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| Nosilec predmeta/Lecturer: |  |

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| Vrsta predmeta/Course type: | Obvezni / Compulsory |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
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| Vsebina: | Content (Syllabus outline): |
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| Temeljna literatura in viri/Readings: |
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| Cilji in kompetence: | Objectives and competences: |
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| Predvideni študijski rezultati: | Intended learning outcomes: |
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| Metode poučevanja in učenja: | Learning and teaching methods: |
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| Načini ocenjevanja: | Delež/Weight | Assessment: |
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| Reference nosilca/Lecturer's references: |
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# Termodinamika materialov Učni načrt predmeta/Course syllabus

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| Predmet: | Termodinamika materialov |
| Course title: | Thermodynamics of Materials |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 1. letnik |  | izbirni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 1. letnik |  | izbirni |

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| Univerzitetna koda predmeta/University course code: | 0076046 |
| Koda učne enote na članici/UL Member course code: | 782 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 45 | 30 | 0 | 0 | 0 | 75 | 5 |

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| Nosilec predmeta/Lecturer: | Primož Ziherl |

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| Vrsta predmeta/Course type: | Izbirni / Elective |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
| Vpis vletnik. | General admission requirements. |

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| Vsebina: | Content (Syllabus outline): |
| **I. Termodinamika čistih snovi:** termodinamični potenciali (energija, entropija), polimorfizem (fazni prehodi, *pT* diagram, fazni prehodi v magnetnih sistemih, polimorfizem pri polimerih).  **II. Termodinamika trdnih raztopin:** razurejene raztopine binarnih sistemov, urejene binarne trdne raztopine, mehanična napetost v trdnih raztopinah, aktivnost in koeficienti aktivnosti raztopin, polimerne zlitine, ravnovesje obremenjene trdnine, tekoče raztopine.  **III. Prosta energija in fazni diagrami binarnih sistemov:** ravnovesje trdne in tekoče faze, evtektična točka v izomorfnih sistemih, ravnovesje trdnih faz, metastabilnost, temperaturna odvisnost faznega diagrama, izračun faznih diagramov.  **IV. Termodinamika površin in majhnih sistemov:** koncept površinskih termodinamičnih količin, izračun površinske energije, rekonstrukcija površin, adsorpcija, površinska napetost, površinska energija (trdnina-plin, kapljevina-plin), stik trdnine in kapljevine ter dveh trdnin, stabilizacija filmov metastabilnih faz, omočitveni prehodi.  **V. Heterofazne in homofazne fluktuacije:** heterofazne fluktuacije, homofazne fluktuacije sestave metastabilne homogene faze, spinodalna krivulja.  **VI. Termodinamika defektov:** elementarne trdnine, zlitine; defekti v kovinah, polprevodnikih in ionskih kristalih, prosta energija defektov.  **VII. Difuzija:** fenomenologija, mehanizmi difuzije (kovine, ionski kristali, polprevodniki), Nernst-Einsteinova relacija, rešitve difuzijske enacbe, področja močne difuzije v trdninah.  VIII. Kinetika nukleacije in rasti: hitrost heterofazne nukleacije, spinodalna dekompozicija, rast po nukleaciji.  **IX. Morfološke nestabilnosti:** nestabilnost reakcijske fronte, dendritično, evtektično strjevanje. | **I. Thermodynamics of pure substances:** thermodynamic potentials (energy, entropy), polymorphism (phase transitions, *pT* diagram, phase transitions in magnetic systems, polymorphism in polymers).  **II. Thermodynamics of solid solutions:** disordered binary solutions, ordered binary solutions, mechanical stress in solid solutions, activity of solutions, polymer melts, equilibrium of a solid under stress, liquid solutions.  **III. Free energy and phase diagrams of binary systems:** solid-liquid equilibrium, eutectic point in isomorphic systems, solid-solid equilibrium, metastability, temperature dependence of phase diagram, computation of phase diagrams.  **IV. Thermodynamics of interfaces and small systems:** surface thermodynamic quantities, evaluation of surface energy, surface reconstruction, adsorption, surface tension, surface energy (solid-gas, liquid-gas), solid-liquid and solid-solid interface, stabilization of films of metastable phases, wetting transitions.  **V. Heterophase and homophase fluctuations:** heterophase fluctuations, homophase fluctuations of composition in metastable homogeneous phase, spinodal line.  **VI. Thermodynamics of defects:** elemental solids, alloys; defects in metals, semiconductors and ionic crystals, free energy of defects.  **VII. Diffusion:** phenomenology, mechanisms of diffusion (metals, ionic crystals, semiconductors), Nernst-Einstein relation, solutions of diffusion equation, regions of fast diffusion in solids.  **VIII. Kinetics of nucleation and growth:** rate of heterophase nucleation, spinodal decomposition, postnucleation growth.  **IX. Morphological instabilities:** reaction front instability, dendritic and eutectic freezing. |

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| Temeljna literatura in viri/Readings: |
| 1. D. R. Gaskell, Introduction to the Thermodynamics of Materials (Taylor & Francis, New York, 2008). 2. D. V. Ragone, Thermodynamycs of Materials Vols. I and II (John Wiley and Sons, New York, 1994). 3. R. DeHoff, Thermodynamics in Materials Science (CRC Press, Boca Raton, 2006). 4. E. Machlin, An Introduction to Aspects of Thermodynamics and Kinetics Relevant for Materials Science (Elsevier, Burlington, 2007). |

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| Cilji in kompetence: | Objectives and competences: |
| poglobiti teoretični vpogled v termodinamiko in fazne spremembe materialov | to extend theoretical knowledge of thermodynamics and phase transitions of materials |

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| Predvideni študijski rezultati: | Intended learning outcomes: |
| Znanje in razumevanje. Osvojitev izbranih zahtevnejših poglavij ravnovesne in neravnovesne termodinamike materialov s poudarkom na površinah in tvorbi faz. Razumevanje vloge termodinamike kot ene od temeljnih ved o snovnih lastnostih. | Knowledge and understanding. The student will deepen his or her insight into selected advanced topics in equilibrium and non-equilibrium thermodynamics of materials, especially those related to surfaces and phase formation. The course will help the student recognize the relevance of thermodynamics as one of the basic materials sciences. |

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| Metode poučevanja in učenja: | Learning and teaching methods: |
| Predavanja, seminarji, vaje , domače naloge in konzultacije. | Lectures, exercises, homework, consultations. |

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| Načini ocenjevanja: | Delež/Weight | Assessment: |
| Izpit pisni ali/in ustni. | 100,00 % | written and/or oral exam |

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| Reference nosilca/Lecturer's references: |
| 1. DOTERA, Tomonari, OSHIRO, Tatsuya, ZIHERL, Primož. Mosaic two-lengthscale quasicrystals. *Nature : the international weekly journal of science*, ISSN 0028-0836. [Print ed.], 2014, vol. 506, no. 7487, str. 208-211. 2. DOTERA, Tomonari, BEKKU, Shinichi, ZIHERL, Primož. Bronze-mean hexagonal quasicrystal. *Nature materials*, ISSN 1476-1122, 2017, vol. 16, no. 16, str. 987-992. 3. ŠIBER, Antonio, ZIHERL, Primož*. Cellular patterns*. Boca Raton: CRC Press, 2018. XIII, 263 str., ilustr. ISBN 978-1-4822-5961-2. |

# Udeležba na predavanjih - 1. letnik Učni načrt predmeta/Course syllabus

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| Predmet: | Udeležba na predavanjih - 1. letnik |
| Course title: | Active Participation in Organized Invited Lectures |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 1. letnik |  | obvezni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 1. letnik |  | obvezni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Rudarstvo in geotehnologija (smer) | 1. letnik |  | obvezni |

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| Univerzitetna koda predmeta/University course code: | 0076017 |
| Koda učne enote na članici/UL Member course code: | 806 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 0 | 0 | 0 | 0 | 150 | 150 | 10 |

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| Nosilec predmeta/Lecturer: |  |

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| Vrsta predmeta/Course type: | Obvezni / Compulsory |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
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| Vsebina: | Content (Syllabus outline): |
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| Temeljna literatura in viri/Readings: |
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| Cilji in kompetence: | Objectives and competences: |
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| Predvideni študijski rezultati: | Intended learning outcomes: |
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| Metode poučevanja in učenja: | Learning and teaching methods: |
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| Načini ocenjevanja: | Delež/Weight | Assessment: |
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| Reference nosilca/Lecturer's references: |
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# Udeležba na predavanjih - 2. letnik Učni načrt predmeta/Course syllabus

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| Predmet: | Udeležba na predavanjih - 2. letnik |
| Course title: | Active Participation in Organized Invited Lectures |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 2. letnik |  | obvezni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 2. letnik |  | obvezni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Rudarstvo in geotehnologija (smer) | 2. letnik |  | obvezni |

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| Univerzitetna koda predmeta/University course code: | 0076021 |
| Koda učne enote na članici/UL Member course code: | 807 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 0 | 0 | 0 | 0 | 150 | 150 | 10 |

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| Nosilec predmeta/Lecturer: |  |

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| Vrsta predmeta/Course type: | Obvezni / Compulsory |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
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| Vsebina: | Content (Syllabus outline): |
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| Temeljna literatura in viri/Readings: |
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| Cilji in kompetence: | Objectives and competences: |
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| Predvideni študijski rezultati: | Intended learning outcomes: |
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| Metode poučevanja in učenja: | Learning and teaching methods: |
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| Načini ocenjevanja: | Delež/Weight | Assessment: |
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| Reference nosilca/Lecturer's references: |
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# Uvajalni seminar Učni načrt predmeta/Course syllabus

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| Predmet: | Uvajalni seminar |
| Course title: | Introductory seminar |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 1. letnik |  | obvezni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 1. letnik |  | obvezni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Rudarstvo in geotehnologija (smer) | 1. letnik |  | obvezni |

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| Univerzitetna koda predmeta/University course code: | 0076018 |
| Koda učne enote na članici/UL Member course code: | 808 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 0 | 0 | 0 | 0 | 75 | 75 | 5 |

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| Nosilec predmeta/Lecturer: |  |

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| Vrsta predmeta/Course type: | Obvezni / Compulsory |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
| Vpis na študij | General admission requirements. |

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| Vsebina: | Content (Syllabus outline): |
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| Temeljna literatura in viri/Readings: |
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| Cilji in kompetence: | Objectives and competences: |
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| Predvideni študijski rezultati: | Intended learning outcomes: |
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| Metode poučevanja in učenja: | Learning and teaching methods: |
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| Načini ocenjevanja: | Delež/Weight | Assessment: |
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| Reference nosilca/Lecturer's references: |
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# Žlindre in talila Učni načrt predmeta/Course syllabus

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| Predmet: | Žlindre in talila |
| Course title: | Slags and fluxes |
| Članica nosilka/UL Member: |  |

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| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Materiali (smer) | 1. letnik |  | izbirni |
| Znanost in inženirstvo materialov, tretja stopnja, doktorski | Metalurgija (smer) | 1. letnik |  | izbirni |

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| Univerzitetna koda predmeta/University course code: | 0076047 |
| Koda učne enote na članici/UL Member course code: | 770 |

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| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
| 30 | 45 | 0 | 0 | 0 | 75 | 5 |

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| Nosilec predmeta/Lecturer: | Jožef Medved, Matjaž Knap, prof. dr. Klaus Koch |

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| Vrsta predmeta/Course type: | Izbirni / Elective |

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| Jeziki/Languages: | Predavanja/Lectures: | Slovenščina |
|  | Vaje/Tutorial: | Slovenščina |

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| Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: | Prerequisites: |
| Splošni pogoji določeni s statutom Univerze v Ljubljani in Oddelka za materiale in metalurgijo, Naravoslovnotehniške fakultete. Poznavanje višje in visokotemperaturnih procesov in uporabe fizikalno-kemičnih zakonitosti pri teh temperaturah. | General admission requirements determined by the Statute of UL. Knowledge of high temperature processes and physical and chemical laws at high temperatures is required. |

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| Vsebina: | Content (Syllabus outline): |
| Žlindre in talila so prisotni v celotnem proizvodnem procesu, njihova sestava in reakcijske sposobnosti pa se spreminjajo in so odvisne od procesno tehnoloških zahtev. Z žlindrami in talili je povezan celoten življenjski krog izdelave in uporabe jekla, drugih kovin in zlitin, metalurške keramike in drugih materialov. Žlindre je nepogrešljiva pri proizvodnih procesih, kjer delamo pri temperaturah nad tališčem materiala, ki je zelo različna, od nekaj sto do nekaj tisoč stopinj. Za njeno tvorbo potrebujemo različne trdne, tekoče in plinaste produkte, ki ustvarjajo nove faze s specifičnimi lastnostmi in oblikami. Specifična posebnost znanstveno raziskovalnega dela na področju žlinder in talil je, da reakcije potekajo v širokem temperaturnem intervalu od nekaj sto stopinj do nekaj tisoč stopinj. Ker z žlindrami uresničujemo kakovostne zahteve proizvedenega materiala so žlindre in talila med izdelavo in predelavo neločljivo povezane s procesno tehnologijo in tehniko. Po končanem procesu pa postanejo sekundarni produkt primarnega proizvodnega procesa materialov. Lahko se uporabijo kot surovina za drug proces ali pa jih lahko s primerno pripravo recikliramo. Glavna naloga sonaravnega razvoja pa je, da so po končanem procesu neškodljive in okolju prijazne. Zaradi razvoja vedno novih materialov na kovinski in nekovinski osnovi v procesni tehniki uporabljamo različne nove legirne elemente in spojine, zato se metalurške lastnosti žlinder spreminjajo in jih moramo z znanstveno raziskovalnim delom znova določati in izpopolnjevati. Področja raziskave žlinder s katerimi se bo doktorand seznanil pri tem predmetu so: - lastnosti tekočih faz, ki sestavljajo žlindre in talila, - struktura in lastnosti tekočih žlinder, - struktura in lastnosti trdnih žlinder, - lastnosti žlinder in talil pri proizvodnih procesih, - ravnotežne in neravnotežne stanja na faznih mejah med žlindro in talino, - vpliv metalurške keramike na mejne plasti in penetrirane cone, - sestava in fazna ravnotežja, - struktura tekočih in trdnih žlinder ter talil, - lastnosti žlinder pri proizvodnji železa, jekla in barvnih kovin, - površinska napetost, viskoznost, toplotna in električna prevodnost žlinder in talil - modeliranje procesov v žlindrinih sistemih, - vpliv fazne sestave na prenos snovi in toplote na faznih mejah, - metalotermično pridobivanje kovin iz žlinder, - povečevanje ekonomike z uporabo žlinder kot sekundarni produkt - metalurška keramika in ognjevzdržna gradiva v proizvodni procesni tehniki - recikliranje žlinder in talil, - odlaganje žlinder in talil ter vpliv na sonaravni razvoj, - vpliv starih odlagališč žlinder na okolje. Če so žlindre in talila za določen proizvodni proces odpadek, pa so lahko za drug proces koristna surovina. S tem se v celotni procesni verigi znižujejo stroški, ker pa je najbolj pomembno, s tem se zmanjšuje obremenitev okolja. | Slags and fluxes are present throughout the production process. Their composition and reaction properties depend on process-technological demands. Slags and fluxes are linked with the entire production cycle and treatment process of steel, other metals and alloys, metallurgical ceramics and other materials. Slags are indispensable in production processes when temperatures are above material melting temperature which can be as high as several hundred or several thousand degrees Celsius. Gaseous, liquid or solid products are needed for their formation, and form new phases with specific characteristics and shapes. For scientific and research work in the area of slags and fluxes it is significant that reactions are carried out within a wide temperature interval, from several hundred to several thousand degrees Celsius. Slags have great impacts on the quality of produced material and are inseparably connected with production technology. After the production they can be treated as secondary products. They can be used as raw material in another process or can be recycled with a proper treatment. The main goal of sustainable development is to make these products harmless and environmental friendly after the process has been completed. Advances in the production of new metallic and non-metallic materials require the use of various new alloys in process techniques thus metallurgical properties of slags are changing and they have to be continuously determined and improved which means continuous scientific and research work. The topics in the area of slag research where students can be involved in during studies are: - properties of liquid phases composed from slags and fluxes, - microstructure and properties of liquid slags, - microstructure and properties of solid slags, - properties of slags and fluxes in industrial production, - equilibrium or nonequilibrium conditions on the interfaces between slag and melt, - influence of metallurgical ceramics on interfaces and penetration zones, - composition and phase equilibrium, - structure and microstructure of liquid and solid slags and fluxes, - properties of slags in production of iron, steel and non-ferrous metals, - surface tension, viscosity, heat and electric conductivity of slags and fluxes, - process modelling in slag systems, - influence of phases on mass and heat transfer at interfaces, - metallothermic extraction of metals from slags, - increasing the production economics by the use of slags as secondary raw material, - metallurgical ceramics and refractory materials in process engineering, - recycling of slags and fluxes, - slag and flux disposal and impacts on sustainable development, - Influence of old slag disposal sites on environment. While slags and fluxes may be considered as waste in some production processes they can be also a useful raw material in others. As such they can lower the costs of production and hence have smaller environmental impacts. |

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| Temeljna literatura in viri/Readings: |
| Molten 2009 - Proceedings of the VIII. International conference on molten slags, fluxes and salts, Santiago, Chile, 18th - 21st January 2009. Santiago: Gecamin, 2009  Euroslag 2008, 5th European Slag Conference, 19th - 21st of September 2007, Luxembourg, Luxembourg, “ZKG International", No. 2, Vol. 61, 2008  Euroslag 2005: Slags – Providing Solutions for Global Construction and other Markets, 4th European Slag Conference Oulu, Finland, 20th - 21st June, 2007  Koch K.**,** Janke Schlacken in der Metallurgie, Verlag Stahleisen, Düsseldorf (1992 - 2. Auflage)  Aktualni članki v revijah kot so: Metallurgical and Materials Transactions A, Metallurgical and Materials Transactions B, ISIJ International, International Journal of Iron and Steel Research, Stahl und Eisen itd. |

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| Cilji in kompetence: | Objectives and competences: |
| Postopki pridobivanja kovin in njihovih zlitin potekajo v ravnotežnih in neravnotežnih pogojih, pri reakcijah med kovinsko talino ter oksidnimi in neoksidnimi talinami – žlindrami in talili. Poznavanje teh medfaznih reakcij in njihovo vodenje k ravnotežnim pogojem določajo procesno tehniko za številne kovine, zlitine in posebno še za pridobivanje čistih kovinskih elementov, ki jih imenujemo novi, napredni materiali. Po drugi strani pa so žlindre in talila po uporabi odvečni produkt, ki ga lahko uporabimo kot sekundarno surovino ali pa ga moramo narediti neškodljivega za okolje. Doktorski študij je namenjen ustvarjanju novega znanja, zato so izobraževalni cilji postavljeni tako, da bo študentu oziroma udeležencem tega študija že znana snov predstavljena tako, da bo na posameznih specifičnih področjih vzbudila pri njih raziskovalni in inovativni pristop k poglabljanju znanja in iskanju novih rešitev. Glavni cilj tega predmeta je pripraviti študenta, da bo sam zaznal in razvijal temeljne inovativne faze procesov (doprinos k znanosti) in dobil sposobnost prenašati inovativne raziskovalne rezultate v uporabo in njihovo komercializacijo. Študenti bodo pridobili toliko teoretičnih znanj, da bodo lahko razvijali novo temeljno znanje, ki je predpogoj za razvijanje novih tehnologij v življenjskem ciklu materialov. | Processes between liquid metals (alloys) and oxide or non-oxide melts (slags and fluxes), which govern metallurgy of metals and alloys taking place in equilibrium or non-equilibrium conditions. Metallurgy of metals, alloys and pure metals (new, modern materials) depends on the knowledge of interphase processes and on production in tendency towards equilibrium conditions. On the other hand, there are slags and fluxes redundant products which can be used as secondary raw materials which need to be changed into environmentally friendly materials. The purpose of doctoral study is to create new knowledge. Thus educational goals are: upgrading the knowledge and stirring up research and professional engagement in a particular scientific topic which will lead to new solutions. The main objective of this course is to prepare students for autonomous work and development of basic innovative solutions for different process stages (scientific contribution). Students should be able to transfer scientific results into practice and their commercialisation. Students will acquire sufficient theoretical knowledge to be able to expand new basic knowledge which is a precondition for the development of new technologies in life-cycle of materials. |

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| Predvideni študijski rezultati: | Intended learning outcomes: |
| Znanje in razumevanje | Knowledge and understanding. |

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| Metode poučevanja in učenja: | Learning and teaching methods: |
| Ker gre za doktorski študij je, v sodelovanju z mentorjem, poudarek na individualnem delu z doktorandom. V obvezni organizirani obliki doktorskega študija bodo metode poučevanja in učenja potekale z uporabo predavanj, vaj, seminarjev in individualnih konzultacij. Na osnovi interesa študenta, povezanega z doktorsko nalogo ali razširitev znanja iz tega področja, se bodo pripravila področja seminarskega dela, ki ga študent samostojno pripravlja s pomočjo mentorja in ga predstavi v obliki krajšega predavanja pred ostalimi slušatelji. | Individual work with candidates. The obligatory part of doctoral study involves: lectures, exercises, seminars and individual consultations. The topic of seminar projects will be chosen on the basis of student’s interest and in relation to their doctoral thesis. Seminar work will be carried out under the supervision of the mentor. Students will present the results to other students in the form of a short lecture. |

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| Načini ocenjevanja: | Delež/Weight | Assessment: |
| Po uspešno predstavljenem seminarju, ki je pogoj za opravljanje ustnega izpita, lahko študent opravlja ustni izpit. Ocena je sestavljena iz ocene seminarja in ocene ustnega izpita. | 100,00 % | After successful seminar presentations candidates can register up for oral exam. Final grade is combination of the grades from seminar and oral exam. |

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| Reference nosilca/Lecturer's references: |
| **Matjaž Knap, doc. dr. (assist. prof. dr.)**   1. LAMUT, Jakob, FALKUS, Jan, JURJEVEC, Beno, KNAP, Matjaž. Influence of inclusions modification on nozzle clogging = Wpływ modyfikacji wtrąceń niemetalicznych na zarastanie wylewów zanurzeniowych. Archives of metallurgy and materials, 2012, vol. 57, no. 1, str. 319-324. [COBISS.SI-ID 1211231] 2. ROZMAN, Alojz, LAMUT, Jakob, DEBELAK, Martin, KNAP, Matjaž. Stabilization of ladle refining slags with borax. V: Slag products - Providing sustainable solutions for the built environment : 5th European Slag Conference : proceedings : 19th - 21st September 2007, Luxembourg, (EUROSLAG publication, no. 4). Duisburg: Euroslag, 2008, str. 137-145. [COBISS.SI-ID 972895] 3. LAMUT, Jakob, KNAP, Matjaž, TOLAR, Mihael, ROZMAN, Alojz. Slag composition in making alloyed steel. V: MARKOVIĆ, Zoran S. (ur.). Proceedings. Bor: Technical Faculty, 2004, 2004, str. 618-626, grafični prikazi. [COBISS.SI-ID 528735]   **Klaus Koch, red. prof. dr. (Full Prof. dr.)**   1. Koch K., Bruckhaus R., Korte E., Roth C., Falkus J.: Optimization of a Channel-type Reactor for Continuous Steelmaking with Water-Oil-Air Models, International Iron Steel Institute Japan Intern. 34 (1994) No. 3, p. 234/240 2. Ren J., Westholt M., Koch K.: The influence of MgO, K2O, Na2O and gas pressure on slag foaming behavior under reducing conditions, Steel Research 65 (1994) No. 6, p. 213/218¸ 3. Koch K.¸ Janke D.: Schlacken in der Metallurgie, Verlag Stahleisen, Düsseldorf (1992 - 2. Auflage), 342 strani   **Jožef Medved, (izr. prof. dr./Assoc. Prof. dr.)**   1. MEDVED, Jože. Novi pogledi na strukturo in fizikalne lastnosti staljenih žlinder. *Rud.-metal. zb.*, 1994, 41, št. 1/2, str. 85-93. 2. GONTAREV, Vasilij, MEDVED, Jože. Equilibrium relations between lead, matte and slag at 1200°C = Ravnotežni odnosi med svincem, kamnom in žlindro pri 1200°C. *RMZ-mater. geoenviron.*, 1999, vol. 46, no. 1, str. 19-24. 3. MEDVED, Jože, LAMUT, Jakob, ZDOVC, Miro, MRVAR, Primož. Influence of SiO2 addition on the properties of Al2O3-CaO-CaF2 slag. *Steel research international*, 2008, vol. 79, no. 12, str. 908-912. |