# KOVINSKI MATERIALI - PAP

# UČNI NAČRT PREDMETA/COURSE SYLLABUS

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| **Predmet:** | Kovinski materiali - PAP |
| **Course title:** | Metals - PAP |
| **Članica nosilka/UL Member:** | UL FS |

| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
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| Strojništvo - projektno aplikativni program, prva stopnja, visokošolski strokovni (od študijskega leta 2025/2026 dalje) | Ni členitve (študijski program) | 1. letnik | 1. semester | obvezni |

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| **Univerzitetna koda predmeta/University course code:** | 0562659 |
| **Koda učne enote na članici/UL Member course code:** | 3004-V |

| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
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| 30 | | 30 | | | 40 | 4 |

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| **Nosilec predmeta/Lecturer:** | Roman Šturm, Zoran Bergant |

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| **Izvajalci predavanj:** | |
| **Izvajalci seminarjev:** | |
| **Izvajalci vaj:** | |
| **Izvajalci kliničnih vaj:** | |
| **Izvajalci drugih oblik:** | |

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| **Izvajalci praktičnega usposabljanja:** | |
| **Vrsta predmeta/Course type:** | Obvezni splošni predmet /Compulsory general course |

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

| **Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:** | **Prerequisites:** |
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| Izpolnjevanje pogojev za vpis v Visokošolski strokovni študijski program I. stopnje Strojništvo - Projektno aplikativni program. | Meeting the enrollment conditions for the MECHANICAL ENGINEERING - Project Oriented Applied Programme. |

| **Vsebina:** | **Content (Syllabus outline):** |
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| 1. Uvod v poznavanje materialov:<br>- razumevanje kristalne zgradbe in mikrostrukture, velikosti kristalov in lastnosti mikrostrukture,<br>- razumevanje nastanka amorfne in kristalne structure, strjevanje taline, ravnotežno in neravnotežno strjevanje, ohlajevalne krivulje.<br>2. Kristalizacija:<br>- osnovne kristalne rešetke, napake v kristalih: točkovne, linijske, površinske in volumske napake,<br>- meje kristalnih zrn v povezavi z mehanskimi lastnostmi,<br>- toplotne lastnosti kovin in zlitin.<br>3. Difuzija:<br>- gibanje atomov v trdnem,<br>- matematični popis stacionarne in nestacionarne difuzije,<br>- vplivni parametri,<br>- Arrheniusovi grafi.<br>4. Mehanske lastnosti materialov:<br>- natezni, tlačni in upogibni preizkus,<br>- diagram napetost-raztezek,<br>- natezna trdnost, meja tečenja, raztezek.<br>- Trdota: pregled postopkov merjenja trdote,<br>5. Mehanske lastnosti materialov: | 1. Introduction:<br>Structure of solid materials: Atoms, atomic bonds, crystal grain, grain boundaries, properties of crystal and amorphous structure, ideal and real crystal structure, melt solidification, cooling curves, equilibrium solidification, non-equilibrium solidification.<br>2. Crystallization:<br>Crystall latice, Types of defects: point, line and two-dimensional defects, volume defects, the importance of material defects, grain boundaries in connection to mechanical properties, thermal properties of metals and alloys.<br>3. Diffusion:<br>atom movements, 1st and 2nd Fick law, influential parameters, Arrhenius graphs<br>4. Mechanical properties of materials:<br>Strength testing: tensile test, tensile strength, yield stress, Flexural strength, Testing hardness: Brinell, Vickers, Rockwell hardness tests, Vickers and Knoop microhardness tests, comparing hardnesses.<br>5. Mechanical properties of materials:<br>Testing impact toughness: impact work, impact toughness, Testing material |

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| - udarna žilavost,<br>- trajna in časovna trdnost,<br>- utrujanje materialov,<br>6. Mehanske lastnosti materialov:<br>- utrjevanje in rekristalizacija,<br>- lezenje materialov.<br>7. Fazni diagrami in zlitine:<br>- definicije in osnovni koncepti,<br>- značilni binarni diagrami,<br>- vzvodno pravilo,<br>- faze in mikrostrukture.<br>8. Sistem Fe-Fe3C:<br>- poznavanje osnovnih mikrostruktur in njihovih lastnosti,<br>- fazne transformacije pri ravnotežnem segrevanju in ohlajanju.<br>9. Jeklo in litine na osnovi železa:o<br>- gljikova jekla,<br>- splošna in posebna konstrukcijska jekla, legirana jekla,<br>- nerjavna jekla,<br>- orodna jekla in super zlitine,<br>- mikrostruktura, lastnosti, uporaba, jeklene litine.<br>10. Lito železo:<br>- siva litina,<br>- bela litina,<br>- temprana litina,<br>- postopki pridobivanja litin,<br>- mikrostruktura v povezavi z lastnostmi in uporabo.<br>11. Osnove toplotne obdelave jekla:f<br>- fazne transformacije v odvisnosti od hitrosti segrevanja in ohlajanja jekla,<br>- kratek pregled postopkov žarjenja, kaljenja, poboljšanja.<br>12. Neželezne kovine in zlitine:<br>- Neželezne kovine in zlitine na osnovi: Al, Mg, Cu (medi, broni), Ti, Ni, Zn, ležajne zlitine, loti.<br>- Utrjevanje s hladno deformacijo, utrjevanje z izločevalnim žarjenjem podprto z mikrostrukturnimi spremembami ter z dodatno hladno deformacijo, mikrostruktura, lastnosti in uporaba neželeznih zlitin.<br>13. Tehnologija litja:<br>- osnove livarstva,<br>- kratek popis livarskih tehnologij,<br>- pregled in uporaba posameznih litin,<br>- lastnosti v povezavi z nastali | strength depending on time and fatigue strength, load cases, Wöhler curve, Smith diagram,<br>6. Mechanical properties of materials: creep, life of machine parts, Larson-Miller diagrams. Work hardening, recrystallization<br>7. Basic phase diagrams:<br>for alloys with no or partial liquid/liquid solubility, alloys with full liquid/liquid solubility and various types of alloys in solid state. Lever rule, phases and microstructures.<br>8. Basics of iron and ferrous alloys:<br>Iron, cooling curves and crystal structure of iron, iron-cementite, iron-graphite phase diagrams, equilibrium heating and cooling, phase transformations.<br>9. Ferrous alloys:<br>General structural steels, a short overview of special structural and tool steels, stainless steel, microstructures, properties, use…<br>10. Cast iron:<br>Gray cast iron, cast iron hardening and tempering processes, nodular graphite cast iron, malleable cast iron, special iron-based castings, properties and use of different types of cast iron.<br>11. Basics of steel heat treatment:<br>phase transformations vs. heating/cooling speed, hardening and tempering of steels and alloys,<br>12. Non-ferrous alloys:<br>Classification of alloys, alloys for casting, alloys for kneading. Overview of aluminium, magnesium, copper alloys (bronze and brass), nickel alloys, zinc alloys, bearing alloys. Heat treatment of non-ferrous alloys, homogenizing and precipitation annealing, cold work hardening, microstructure…<br>13. Casting:<br>Mould manufacturing, casting processes (sand casting, chill casting, die casting), special casting processes. Melt solidification and formation of casting cavity/casting, casting defects, cast microstructure and microstructural strength. Homogenizing annealing of |

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| mikrostrukturo.<br>14. Prašna metalurgija (sintranje):<br>- pridobivanje prahu, priprava prahu,<br>- stiskanje, sintranje,<br>- dodatne obdelave,<br>- področja uporabe, vrste in uporaba pomembnih železnih in neželeznih zlitin pridobljenih po prašni metalurgiji,<br>- posebni izdelki pridobljeni s prašno metalurgijo, mehanske lastnosti takih izdelkov.<br>15. Korozija in zaščita pred korozijo:<br>- osnove kemične in elektrokemične korozije, oksidacijski kriterij,<br>- pregled vrst korozije,<br>- pregled mehanskih, kemičnih in elektrokemičnih postopkov zaščite; potapljanje, metalizacija, različni postopki barvanja in lakiranja. | castings and stress-free annealing.<br>14. Powder metallurgy technology and sintered materials:<br>Production and preparation of powder, pressing and sintering, overview of different technological processes of sintering, diffusion processes in sintering, a short overview of sintered steels and non-ferrous alloys, product design for powder metallurgy, aftertreatment of sintered parts, properties of sintered materials, standard sintered materials and use: structural parts, bearing alloys, filters, brake pads<br>15. Corrosion and corrosion protection:<br>manifestations of corrosion, rate of electro-chemical reactions, testing for corrosion, rate of corrosion, types and properties of different forms of corrosion, overview of corrosion-protection processes: mechanical, chemical and electro-chemical, immersion, galvanic, diffusion etc |

**Temeljna literatura in viri/Readings:**


1. D. R. Askeland: The science and engineering of materials, Sixth Edition, Chapman & Hall, London, 2011 [COBISS.SI-ID 5321057]
2. K. Cummings, P. Laws, E. Redish and P. Cooney: Understanding physics, John Wiley & sons, Inc. USA, 2004 [COBISS.SI-ID 9965878]
3. M. Philip, B. Bolton: Technology of engineering materials, Butterworth Heinemann, Oxford, 2007 [COBISS.SI-ID 5489947]
4. W. Bolton: Engineering materials technology, Third edition, Butterworth Heinemann, Oxford, 1998 [COBISS.SI-ID 19664645]
5. J.F.Shackelford: Introduction to materials science for engineers, fifth edition, Prentince Hall, 2000 [COBISS.SI-ID 3921435]
6. Moderno proizvodno inženirstvo, priročnik, ur. Karl Kuzman, Grafis trade, 2010 [COBISS.SI-ID 244690944]


| **Cilji in kompetence:** | **Objectives and competences:** |
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| Cilji:<br>1. Osnove o razumevanju lastnosti materialov z vidika kristalne zgradbe in mikrostrukture v povezavi z mehanskimi lastnostmi.<br>2. Znanje o zlitinah in zlitinskih sistemih, o nastalih mikrostrukturah, | Objectives:<br>1. Familiarity with material properties: connection of cristal lattice and microstructure with mechanical properties.<br>2. Getting the knowledge of alloys and alloying systems, microstructures, |

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| o vplivu primarnega pridobivanja zlitine oziroma materiala.<br>3. Poznavanje osnovnih kovinskih materialov in njihovih lastnostih, poznavanje vpliva legiranja na mehanske lastnosti.<br><br>Kompetence:<br><br>1. S1,S2-PAP + P1,P3,P4-PAP: Sposobnost ocenjevanja lastnosti materialov z vidika nastale mikrostrukture, Dobro poznavanje postopkov preizkušanja materialov in načinov prikaza lastnosti materialov glede na stanje materialov.<br>2. S1,S2-PAP + P1,P3,P4-PAP: Pozna tehnologijo pridobivanja posameznih vrst materialov oziroma polizdelkov, zato razume tudi lastnosti in uporabnost le teh.<br>3. S1,S2-PAP + P1,P3,P4,P8-PAP: Razume značilne razlike v lastnostih in uporabnosti posameznih vrst materialov.<br><br>S1,S2,S13-PAP + P1,P3,P4,P8-PAP: Sposobnost izbiranja materialov pri snovanju izdelkov in konstruiranju. | the influence of material production on mechanical properties.<br>3. Getting the knowledge about basic metal materials and their properties; and the influence of alloying on mechanical properties.<br><br>Competences:<br><br>1. S1,S2-PAP + P1,P3,P4-PAP: Ability to evaluate material properties according to the microstructure. Good knowledge of materials testing procedures and methods of demonstrating material properties with respect to the state of materials.<br>2. S1,S2-PAP + P1,P3,P4-PAP: Knowing material or semi-finished products production technology to understand its properties and use.<br>3. S1,S2-PAP + P1,P3,P4,P8-PAP: Understanding characteristic differences in properties and in usefulness of different materials.<br><br>S1,S2,S13-PAP + P1,P3,P4,P8-PAP: Ability to choose proper material in designing products. |

| **Predvideni študijski rezultati:** | **Intended learning outcomes:** |
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| Znanja:<br><br>Študent pridobi znanje o mehanskih in nekaterih fizikalnih lastnosti materialov. Spozna osnovne postopke izdelave polizdelkov s poudarkom na lastnostih materialov iz ocenjevanja mikrostrukture. Študent pridobi sposobnost ocenjevanja in primerjave podatkov o materialih – zlitinah, ki so podani v priročnikih v tabelarični obliki ali v diagramih.…<br><br>Spretnosti:<br><br>S1.1. Priprava vzorcev za določevanje mikrostrukture in mehanskih lastnosti materiala<br><br>S1.2 Odčitavanje in analiza mehanskih lastnosti materiala iz grafov ali tabel<br><br>S1.3 Izbira materiala glede mehanskih zahtev | Knowledge:<br><br>The student acquires knowledge of the mechanical and some physical properties of the materials. Understands basic manufacturing processes for semi-finished products with a focus on the properties of materials from microstructure evaluation. The student acquires the ability to evaluate and compare data on materials - alloys, which are given in manuals in tabular form or in diagrams.<br><br>Skills:<br>S1.1 Preparation of specimens for determining the mechanical properties of a material.<br><br>S1.2 Reading and analysis of mechanical properties of material from graphs or table. |

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| | S1.3 Selection of material for mechanical requirements. |

| **Metode poučevanja in učenja:** | **Learning and teaching methods:** |
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| 1. P1 – avditorna predavanja<br>2. P2 – obravnava snovi po urejeni in v naprej razloženi sistematiki<br>3. P3 – avditorne in laboratorijske vaje<br>4. P5 – uporaba študijskega gradiva v obliki knjig, zapiskov predavanj – tiskana oblika, e-zapiski predavanj. | 1. P1 Auditorial lectures.<br>2. P2 Treats substances according to an orderly and systematic explanation<br>3. P3 Auditorial and laboratory exercises.<br>4. P5 Application of study material (textbook, e-book, printed lecture presentations). |

| **Načini ocenjevanja:** | **Delež/ Weight** | **Assessment:** |
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| - Teoretične vsebine (predavanja) | 70,00 % | - Theoretical content (lectures) |
| - Delo na vajah (vključno s poročili) | 30,00 % | - Laboratory work (including reports) |

| **Ocenjevalna lestvica:** | **Grading system:** |
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| 5 - 10, pri čemer velja, da je pozitivna ocena od 6 - 10 | 5 - 10, a student passes the exam if he is graded from 6 to 10 |

**Reference nosilca/Lecturer's references:**

**Roman Šturm:**

1. STEINER PETROVIČ, Darja, **ŠTURM, Roman**, NAGLIČ, Iztok, MARKOLI, Boštjan, PEPELNJAK, Tomaž. Microstructural anisotropy of magnetocaloric gadolinium cylinders : effect on the mechanical properties of the material. Materials, ISSN 1996-1944, 2016, vol. 9, iss. 5, str. 1-14, ilustr. http://www.mdpi.com/1996-1944/9/5/382, doi: 10.3390/ma9050382. [COBISS.SI-ID 1206698],
2. **ŠTURM, Roman**, ŽNIDARŠIČ, Matjaž, GRUM, Janez. Crack-growth behavior of laser surface-alloyed low-carbon steel. Journal of materials engineering and performance, ISSN 1059-9495, Sep. 2013, vol. 22, iss. 9, str. 2542-2549, ilustr., doi: 10.1007/s11665-013-0549-4. [COBISS.SI-ID 12816667],
3. **ŠTURM, Roman**, GRUM, Janez, BOŽIČ, Slavko. Influence of the alloying elements in Al-Si alloys on the laser remelting process. Lasers in engineering, ISSN 0898-1507, 2012, vol. 22, no. 1/2, str. 47-61. [COBISS.SI-ID 11872539],
4. GRUM, Janez, **ŠTURM, Roman**. Residual stress profiles of the laser surface remelted nodular irons. Materials science forum, ISSN 0255-5476, 2005, letn. 490/491, str. 460-468. [COBISS.SI-ID 7904795],
5. **ŠTURM, Roman**, GRUM, Janez. Residual stresses after laser surface remelting of cast iron as a function of microstructure constituents. V: OSTOJA-STARZEWSKI, Martin (ur.), MARZOCCA, P. (ur.). Thermal stresses 2009 : proceedings of The Eighth International Congress on Thermal Stresses, 1-4 June

2009, Illinois, USA. Illinois: The Board of Trustees of the University. 2009, str. 215-218. [COBISS.SI-ID 11034139] – vabljeno predavanje

**Zoran Bergant**:

1. **BERGANT, Zoran**, ŠETINA, Barbara, FELDE, Imre, ŠTURM, Roman, SEDLAČEK, Marko. Tribological properties of solid solution strengthened laser cladded NiCrBSi/WC-12Co metal matrix composite coatings. *Materials*. 2022, vol. 15, iss. 1, str. 1-20, ilustr. ISSN 1996-1944. https://www.mdpi.com/1996-1944/15/1/342, DOI: 10.3390/ma15010342. [COBISS.SI-ID 92175107]
2. **BERGANT, Zoran**, SAVIN, Adriana, GRUM, Janez. Effects of manufacturing technology on static, multi-frequency dynamic mechanical analysis and fracture energy of cross-ply and quasi-isotropic carbon/epoxy laminates. *Polymers & polymer composites : incorporating Engineering plastics*. 2018, vol. 26, iss. 5/6, str. 358-370, ilustr. ISSN 0967-3911. http://journals.sagepub.com/doi/abs/10.1177/0967391118798266, DOI: 10.1177/0967391118798266. [COBISS.SI-ID 16300571]
3. **BERGANT, Zoran**, TRDAN, Uroš, GRUM, Janez. Effects of laser shock processing on high cycle fatigue crack growth rate and fracture toughness of aluminium alloy 6082-T651. *International journal of fatigue*. Jun. 2016, vol. 87, str. 444-455, ilustr. ISSN 0142-112 DOI: 10.1016/j.ijfatigue.2016.02.027. [COBISS.SI-ID 14539035]
4. **BERGANT, Zoran**, FELDE, Imre, GRUM, Janez. Modelling of remelted and heat affected zone during laser alloying of C45 steel with nickel-based powder. *International journal of microstructure and materials properties*. 2015, vol. 10, iss. 2, str. 129-139, ilustr. ISSN 1741-8410. http://www.inderscienceonline.com/doi/pdf/10.1504/IJMMP.2015.068716, DOI: 10.1504/IJMMP.2015.068716. [COBISS.SI-ID 14715419]
5. **BERGANT, Zoran**, TRDAN, Uroš, GRUM, Janez. Effect of high-temperature furnace treatment on the microstructure and corrosion behaviour of NiCrBSi flame-sprayed coatings. *Corrosion science*. [Print ed.]. Nov. 2014, vol. 88, str. 372-386, ilustr. ISSN 0010-938X. DOI: 10.1016/j.corsci.2014.07.057. [COBISS.SI-ID 13639195]