

KOVINSKI MATERIALI - PAP

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet: Kovinski materiali - PAP

Course title: Metals - PAP

Članica nosilka/UL Member: UL FS

Študijski programi in stopnja

Študijska smer

Letnik

Semestri

Izbirnost

Strojništvo - projektno aplikativni program, prva stopnja, visokošolski strokovni (od študijskega leta 2025/2026 dalje)

Ni členitve (študijski program)

1. letnik

1. semester

obvezni

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

30

30

40

4

Nosilec predmeta/Lecturer:

Roman Šturm, Zoran Bergant

Izvajalci predavanj:

Izvajalci seminarjev:

Izvajalci vaj:

Izvajalci kliničnih vaj:

Izvajalci drugih oblik:

Izvajalci praktičnega usposabljanja:

Vrsta predmeta/Course type:

Obvezni splošni predmet /Compulsory general course

Jeziki/Languages:

Predavanja/Lectures:

Slovenščina

Vaje/Tutorial:

Slovenščina

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:

Prerequisites:

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):

1. Uvod v poznavanje materialov:
 - razumevanje kristalne zgradbe in mikrostrukture, velikosti kristalov in lastnosti mikrostrukture,
 - razumevanje nastanka amorfnosti in kristalne strukture, strjevanje taline, ravnotežno in neravnotežno strjevanje, ohlajevalne krivulje.
2. Kristalizacija:
 - osnovne kristalne rešetke, napake v kristalih: točkovne, linijske, površinske in volumnske napake,
 - meje kristalnih zrn v povezavi z mehanskimi lastnostmi,
 - toplotne lastnosti kovin in zlitin.
3. Difuzija:
 - gibanje atomov v trdnem,
 - matematični popis stacionarne in nestacionarne difuzije,
 - vplivni parametri,
 - Arrheniusovi grafi.
4. Mehanske lastnosti materialov:
 - natezni, tlačni in upogibni preizkus,
 - diagram napetost-raztezek,
 - natezna trdnost, meja tečenja, raztezek.
 - Trdota: pregled postopkov merjenja trdote,
5. Mehanske lastnosti materialov:

1. Introduction:
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.
2. Crystallization:
Crystall lattice, 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.
3. Diffusion:
atom movements, 1st and 2nd Fick law, influential parameters, Arrhenius graphs
4. Mechanical properties of materials:
Strength testing: tensile test, tensile strength, yield stress, Flexural strength, Testing hardness: Brinell, Vickers, Rockwell hardness tests, Vickers and Knoop microhardness tests, comparing hardnesses.
5. Mechanical properties of materials:
Testing impact toughness: impact work, impact toughness, Testing material

<ul style="list-style-type: none"> - udarna žilavost, - trajna in časovna trdnost, - utrujanje materialov, <p>6. Mehanske lastnosti materialov:</p> <ul style="list-style-type: none"> - utrjevanje in rekristalizacija, - lezenje materialov. <p>7. Fazni diagrami in zlitine:</p> <ul style="list-style-type: none"> - definicije in osnovni koncepti, - značilni binarni diagrami, - vzvodno pravilo, - faze in mikrostrukture. <p>8. Sistem Fe-Fe₃C:</p> <ul style="list-style-type: none"> - poznavanje osnovnih mikrostruktur in njihovih lastnosti, - fazne transformacije pri ravnotežnem segrevanju in ohlajanju. <p>9. Jeklo in litine na osnovi železa:</p> <ul style="list-style-type: none"> - gljikova jekla, - splošna in posebna konstrukcijska jekla, legirana jekla, - nerjavna jekla, - orodna jekla in super zlitine, - mikrostruktura, lastnosti, uporaba, jeklene litine. <p>10. Lito železo:</p> <ul style="list-style-type: none"> - siva litina, - bela litina, - temprana litina, - postopki pridobivanja litin, - mikrostruktura v povezavi z lastnostmi in uporabo. <p>11. Osnove toplotne obdelave jekla:</p> <ul style="list-style-type: none"> - fazne transformacije v odvisnosti od hitrosti segrevanja in ohlajanja jekla, - kratek pregled postopkov žarjenja, kaljenja, poboljšanja. <p>12. Neželezne kovine in zlitine:</p> <ul style="list-style-type: none"> - Neželezne kovine in zlitine na osnovi: Al, Mg, Cu (medi, broni), Ti, Ni, Zn, ležajne zlitine, loti. - Utrjevanje s hladno deformacijo, utrjevanje z izločevalnim žarjenjem podprto z mikrostrukturnimi spremembami ter z dodatno hladno deformacijo, mikrostruktura, lastnosti in uporaba neželeznih zlitin. <p>13. Tehnologija litja:</p> <ul style="list-style-type: none"> - osnove livarstva, - kratek popis livarskih tehnologij, - pregled in uporaba posameznih litin, - lastnosti v povezavi z nastali 	<p>strength depending on time and fatigue strength, load cases, Wöhler curve, Smith diagram,</p> <p>6. Mechanical properties of materials: creep, life of machine parts, Larson-Miller diagrams. Work hardening, recrystallization</p> <p>7. Basic phase diagrams: 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.</p> <p>8. Basics of iron and ferrous alloys: Iron, cooling curves and crystal structure of iron, iron-cementite, iron-graphite phase diagrams, equilibrium heating and cooling, phase transformations.</p> <p>9. Ferrous alloys: General structural steels, a short overview of special structural and tool steels, stainless steel, microstructures, properties, use...</p> <p>10. Cast iron: 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.</p> <p>11. Basics of steel heat treatment: phase transformations vs. heating/cooling speed, hardening and tempering of steels and alloys,</p> <p>12. Non-ferrous alloys: 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...</p> <p>13. Casting: 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</p>
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<p>mikrostrukturo.</p> <p>14. Prašna metalurgija (sintranje):</p> <ul style="list-style-type: none"> - pridobivanje prahu, priprava prahu, - stiskanje, sintranje, - dodatne obdelave, - področja uporabe, vrste in uporaba pomembnih železnih in neželeznih zlitin pridobljenih po prašni metalurgiji, - posebni izdelki pridobljeni s prašno metalurgijo, mehanske lastnosti takih izdelkov. <p>15. Korozija in zaščita pred korozijo:</p> <ul style="list-style-type: none"> - osnove kemične in elektrokemične korozije, oksidacijski kriterij, - pregled vrst korozije, - pregled mehanskih, kemičnih in elektrokemičnih postopkov zaščite; potapljanje, metalizacija, različni postopki barvanja in lakiranja. 	<p>castings and stress-free annealing.</p> <p>14. Powder metallurgy technology and sintered materials: 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</p> <p>15. Corrosion and corrosion protection: 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</p>
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Temeljna literatura in viri/Readings:

<ol style="list-style-type: none"> 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, Prentice Hall, 2000 [COBISS.SI-ID 3921435] 6. Moderno proizvodno inženirstvo, priročnik, ur. Karl Kuzman, Grafis trade, 2010 [COBISS.SI-ID 244690944]
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Cilji in kompetence:

Cilji:	Objectives and competences:
<ol style="list-style-type: none"> 1. Osnove o razumevanju lastnosti materialov z vidika kristalne zgradbe in mikrostrukture v povezavi z mehanskimi lastnostmi. 2. Znanje o zlitinah in zlitinskih sistemih, o nastalih mikrostrukturah, 	<ol style="list-style-type: none"> 1. Familiarity with material properties: connection of cristal lattice and microstructure with mechanical properties. 2. Getting the knowledge of alloys and alloying systems, microstructures,

<p>o vplivu primarnega pridobivanja zlitine oziroma materiala.</p> <p>3. Poznavanje osnovnih kovinskih materialov in njihovih lastnosti, poznavanje vpliva legiranja na mehanske lastnosti.</p> <p>Kompetence:</p> <p>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.</p> <p>2. S1,S2-PAP + P1,P3,P4-PAP: Pozna tehnologijo pridobivanja posameznih vrst materialov oziroma polizdelkov, zato razume tudi lastnosti in uporabnost le teh.</p> <p>3. S1,S2-PAP + P1,P3,P4,P8-PAP: Razume značilne razlike v lastnostih in uporabnosti posameznih vrst materialov.</p> <p>S1,S2,S13-PAP + P1,P3,P4,P8-PAP: Sposobnost izbiranja materialov pri snovanju izdelkov in konstruiranju.</p>	<p>the influence of material production on mechanical properties.</p> <p>3. Getting the knowledge about basic metal materials and their properties; and the influence of alloying on mechanical properties.</p> <p>Competences:</p> <p>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.</p> <p>2. S1,S2-PAP + P1,P3,P4-PAP: Knowing material or semi-finished products production technology to understand its properties and use.</p> <p>3. S1,S2-PAP + P1,P3,P4,P8-PAP: Understanding characteristic differences in properties and in usefulness of different materials.</p> <p>S1,S2,S13-PAP + P1,P3,P4,P8-PAP: Ability to choose proper material in designing products.</p>
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<p>Predvideni študijski rezultati:</p> <p>Znanja:</p> <p>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....</p> <p>Spretnosti:</p> <p>S1.1. Priprava vzorcev za določevanje mikrostrukture in mehanskih lastnosti materiala</p> <p>S1.2 Odčitavanje in analiza mehanskih lastnosti materiala iz grafov ali tabel</p> <p>S1.3 Izbira materiala glede mehanskih zahtev</p>	<p>Intended learning outcomes:</p> <p>Knowledge:</p> <p>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.</p> <p>Skills:</p> <p>S1.1 Preparation of specimens for determining the mechanical properties of a material.</p> <p>S1.2 Reading and analysis of mechanical properties of material from graphs or table.</p>
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	S1.3 Selection of material for mechanical requirements.
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Metode poučevanja in učenja:	Learning and teaching methods:
1. P1 – avditorna predavanja 2. P2 – obravnava snovi po urejeni in v naprej razloženi sistematiki 3. P3 – avditorne in laboratorijske vaje 4. P5 – uporaba študijskega gradiva v obliki knjig, zapiskov predavanj – tiskana oblika, e-zapiski predavanj.	1. P1 Auditorial lectures. 2. P2 Treats substances according to an orderly and systematic explanation 3. P3 Auditorial and laboratory exercises. 4. P5 Application of study material (textbook, e-book, printed lecture presentations).

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

Ocenjevalna lestvica:	Grading system:
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
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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](#)]