

## UČNI NAČRT PREDMETA/COURSE SYLLABUS

<b>Predmet:</b>	Kovinski materiali - RRP
<b>Course title:</b>	METALS - RRP
<b>Članica nosilka/UL Member:</b>	UL FS

Študijski programi in stopnja	Študijska smer	Letnik	Semestri
Strojništvo - razvojno raziskovalni program, prva stopnja, univerzitetni	Ni členitve (študijski program)	1. letnik	2. semester

**Univerzitetna koda predmeta/University course code:** 0577584

**Koda učne enote na članici/UL Member course code:** 2010-U

Predavanja	Seminar	Vaje	Klinične vaje	Druge oblike študija	Samostojno delo	ECTS
30		30			40	4

**Nosilec predmeta/Lecturer:** Roman Šturm

**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 Univerzitetni študijski program I. stopnje Strojništvo - Razvojno raziskovalni program.

Meeting the enrollment conditions for the Academic study programme of Mechanical Engineering - Research and Development program.

**Vsebina:**

**Content (Syllabus outline):**

1. RAZDELITEV KOVINSKIH MATERIALOV:  
- železne in neželezne zlitine, razdelitev po različnih kriterijih: kemijski sestavi, mehanskih lastnosti, fizikalnih lastnosti, odpornosti na korozijo, obdelovalnosti, temperaturne obstojnosti, klasifikacija označevanja.  
2. NASTANEK KOVINSKIH MATERIALOV OD TALINE DO TRDNEGA STANJA:  
- strjevanje taline, vpliv hitrosti strjevanja na velikost zrn, določevanje velikosti zrn..., kristalne rešetke, vrste napak v mikrostrukturi, vpliv napak na mehanske lastnosti materialov... Izbira materiala glede na vrsto

1. CLASSIFICATION OF METAL ALLOYS: ferrous and non-ferrous alloys, classification according chemical composition, mechanical properties, physical properties, corrosion resistance, machinability, temperature resistance, ...  
2. COOLING CURVES:  
Thermodynamic and kinetic interpretation of metals crystallization, nucleation in liquid state, crystallization process, crystal boundaries, dendritic structures, defects, choice of material regarding crystal lattice.

kristalne rešetke.

### 3. LITJE:

- popis osnovnih tehnologij litja, določevanje vpliva mase na velikost zrn in na mehanske lastnosti, napake v ulitkih, lita mikrostruktura v povezavi s trdnostjo materiala, homogenizacija ulitkov in priprava za nadaljnjo predelavo polizdelkov, izbira ustreznega postopka litja za izdelek/polizdelek.

### 4. FAZNI DIAGRAMI:

- osnovni diagrami stanja za zlitine popolno netopne in delno topne v tekočem stanju, za zlitine popolno topne v tekočem stanju in delno/popolno topne v trdnem stanju. Izbiranje materialov glede na delež legirnih elementov in njihovo topnost v povezavi z mehanskimi lastnostmi.

### 5. DIFUZIJSKI IN BREZDIFUZIJSKI PROCESI:

- zmožnost gibanja atomov v trdnem, 1. in 2. Fickov zakon. Razumevanje legiranja kovin na atomskem in na mikro nivoju, difuzijsko žarjenje za izenačevanje kemijske sestave po preseku izdelka, lastnosti difuzijskih/adhezijskih/metalurških spojev, leženje materiala, aplikacije v energetiki.

### 6. SINTRANI MATERIALI:

- kratek popis tehnologije prahov, priprava prahu, prešanje in sintranje, kratek pregled sintranih jekel in kovinskih neželeznih zlitin, mehanske lastnosti sintranih izdelkov v primerjavi z litimi, razredi sintranih materialov, aplikativni primeri.

### 7. MEHANSKE LASTNOSTI MATERIALOV 1:

- elastična in plastična deformacija materialov, določevanje natezne trdnosti, meje tečenja, modula elastičnosti, razteznosti materiala na osnovi preizkusov trdnosti: natezni, tlačni, upogibni test, določevanje trdote mehkim in trdim materialom: po Brinellu, Vickersu, Rockwellu, izbira materiala za izbrano aplikacijo po tabelah glede trdote, trdnosti, duktilnosti.

### 8. MEHANSKE LASTNOSTI MATERIALOV 2:

- Izbira materiala glede na zahtevano žilavost, vplivi na udarno žilavost, plastični in krhki zlom. Izbira materiala pri utrujanju, življenjska doba, določevanje časovne in trajne dinamične trdnosti materialov, odčitavanje podatkov iz Woehlerjevih krivulj in Smithovih diagramov. Določevanje udarne žilavosti in dobe trajanja pri različnih obratovalnih temperaturah.

### 9. ŽELEZO IN ŽELEZNE ZLITINE:

- železo, ohlajevalna krivulja in kristalna zgradba železa, diagram stanja železo – cementit, ravnotežno segrevanje in ohlajanje, kristalna zgradba posameznih faz, mikrostrukture v diagramu železo – cementit. Neravnotežno ohlajanje avstenita in vpliv na mehanske lastnosti-kaljenje.

### 10. IZBIRA OGLJIKOVEGA JEKLA:

- določevanje aplikacije za železne zlitine različnih kemijskih sestav, na osnovi merila natezne trdnosti,

### 3. CASTING:

ingot casting, continuous casting, shape casting, rules in casting technology, homogenization annealing of castings, properties of castings, use of modifiers, control of the process of crystallization segregations, flaws and defects due to shrinking, shrinkage cavities, porosity, residual stresses, geometric distortion, stress annealing of castings.

### 4. PHASE DIAGRAMS:

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. The presentation is backed by crystal structure – microstructure and properties.

### 5. DIFFUSION AND MARTENSITIC TRANSFORMATIONS:

atom movements, 1st and 2nd Fick law, understanding of alloying process, diffusion and homogenization annealing, properties of diffusion joint, creep,...

### 6. 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, properties of sintered materials, standard sintered materials and use: structural parts, bearing alloys, filters, brake pads

### 7. MECHANICAL PROPERTIES OF MATERIALS 1:

Strength testing: tensile test, tensile strength, yield stress, ability to deform under tensile stress (ductility), presentation of standard data. Flexural strength, measuring bending, determination of bending number. Testing hardness: Brinell, Vickers, Rockwell hardness tests, Vickers and Knoop microhardness tests, comparing hardnesses.

### 8. MECHANICAL PROPERTIES OF MATERIALS 2:

Testing impact toughness: impact work, impact toughness, factors influencing impact toughness, plastic and brittle fracture; Testing material strength depending on time and fatigue strength, load cases, Wöhler curve, Smith diagram, using data from the diagram, factors influencing the dynamic strength of materials, fracture formation, characterization of dynamically loaded parts.

### 9. 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. Mechanical properties.

### 10. FERROUS ALLOYS SELECTION:

General structural steels, properties and use of structural steels for heat treatment, a short overview of structural steels on tensile strength, hardness, toughness, ductility... Use of tables, graphs...

<p>trdote, žilavosti, duktilnosti, koeficienta trenja, ... Uporaba priročnikov, table, grafov.</p> <p>11. IZBIRA LEGIRANEGA JEKLA:</p> <ul style="list-style-type: none"> <li>- malo-legirana, visoko-legirana jekla, splošna konstrukcijska jekla, jekla za poboljšanje, kotelska pločevina, jekla za visoko-temperaturne aplikacije, jekla odporna na obrabo, jekla odporna na korozijo, orodna jekl. Odločitveni grafi za izbiro ustreznega jekla.</li> </ul> <p>12. OPLEMENITENJE POVRŠINE JEKEL:</p> <ul style="list-style-type: none"> <li>- procesi za povečanje korozijske odpornosti, trdote, za zmanjšanje trenja. Difuzijske in brezdifuzijske transformacije. Povezava doseženih lastnosti z aplikacijo v industriji.</li> </ul> <p>13. LITO ŽELEZO:</p> <ul style="list-style-type: none"> <li>- siva litina, nodularna litina, bela litina, temprana litina, vpliv vrste mikrostrukture na mehanske lastnosti. Uporaba različnih litin in njihova toplotna obdelava za tipične aplikacije. Mehanske lastnosti teh litin.</li> </ul> <p>14. LAHKE NEŽELEZNE ZLITINE:</p> <ul style="list-style-type: none"> <li>- zlitine Al, Mg, Ti, mehanske lastnosti, vpliv legiranja na lastnosti, mikrostrukture, odpornost na okolico. Vpliv toplotne obdelave na trdnost. Izbira materiala na kriterijih specifične trdnosti, specifične togosti...</li> </ul> <p>15. TEŽKE NEŽELEZNE ZLITINE:</p> <ul style="list-style-type: none"> <li>- Cu, Ni, medenina, broni, njihova toplotna obdelava, mikrostruktura in kemijska sestava v povezavi z mehanskimi lastnostmi, uporaba... obdelovalne lastnosti, lastnosti površin, temperaturna odvisnost.</li> </ul>	<p>11. TOOL STEELS SELECTION: a short overview of tool steels, heat treatable tool steels, properties of tool steels. Use of tables, graphs...</p> <p>12. LOCAL AND CASE HARDENING: sinking, flame, inductive, laser hardening; choosing a process and its performance, microstructure and surface properties. Different heat treatment processes of case hardening, properties and industrial use.</p> <p>13. CAST IRON: Gray cast iron, cast iron hardening and tempering processes, nodular graphite cast iron, steel castings, malleable cast iron, special iron-based castings, properties and use of different types of cast iron.</p> <p>14. NON-FERROUS ALLOYS 1: Classification of alloys, alloys for casting, alloys for kneading. Overview of aluminium, magnesium, Titanium alloys . Alloying and heat treatment of non-ferrous alloys, the size of precipitates and the achieved hardness and strength of materials for typical alloys, material selection upon specific strength...</p> <p>15. NON-FERROUS ALLOYS 2: Overview of copper alloys (bronze and brass), nickel alloys, zinc alloys, bearing alloys. Heat treatment in conjunction to mechanical properties and the achieved hardness</p>
-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

#### Temeljna literatura in viri/Readings:

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

#### Cilji in kompetence:

##### Cilji:

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, o vplivu primarnega pridobivanja zlitine oziroma materiala na mehanske lastnosti.
3. Poznavanje osnovnih kovinskih materialov in njihovih lastnostih, poznavanje vpliva legiranja na mehanske lastnosti.

##### Kompetence:

1. Sposobnost ocenjevanja lastnosti materialov z

#### Objectives and competences:

##### Objectives:

1. Familiarity with material properties: connection of crystal lattice and microstructure with mechanical properties.
2. Getting the knowledge of alloys and alloying systems, microstructures, the influence of material production on mechanical properties.
3. Getting the knowledge about basic metal materials and their properties; and the influence of alloying on mechanical properties.

##### Competences:

1. Ability to evaluate material properties according to

<p>vidika nastale mikrostrukture (S1-RRP + P1,P2,P3-RRP).</p> <p>2. Pozna tehnologijo pridobivanja posameznih vrst materialov oziroma polizdelkov, zato razume tudi lastnosti in uporabnost le teh (S6-RRP + P1,P2,P3-RRP).</p> <p>3. Razume značilne razlike v lastnostih in uporabnosti posameznih vrst materialov (S1-RRP + P1,P2,P3-RRP).</p> <p>4. Sposobnost izbiranja materialov pri snovanju izdelkov in konstruiranju (S6-RRP + P1,P2,P3-RRP).</p>	<p>the microstructure (S1-RRP + P1,P2,P3-RRP).</p> <p>2. Knowing material or semi-finished products production technology to understand its properties and use. (S6-RRP + P1,P2,P3-RRP).</p> <p>3. Understanding characteristic differences in properties and in usefulness of different materials (S1-RRP + P1,P2,P3-RRP).</p> <p>4. Ability to choose proper material in designing products (S6-RRP + P1,P2,P3-RRP).</p>
-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

#### Predvideni študijski rezultati:

<p><b>Znanja:</b></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 tabelarni obliki ali v diagramih....</p> <p><b>Spretnosti:</b></p> <p>S1.1 Priprava vzorcev za določevanje 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><b>Knowledge:</b></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><b>Skills:</b></p> <table><tr><td>S1.1 Preparation of specimens for determining the mechanical properties of a material.</td></tr><tr><td>S1.2 Reading and analysis of mechanical properties of material from graphs or table.</td></tr><tr><td>S1.3 Selection of material for mechanical requirements.</td></tr></table>	S1.1 Preparation of specimens for determining the mechanical properties of a material.	S1.2 Reading and analysis of mechanical properties of material from graphs or table.	S1.3 Selection of material for mechanical requirements.
S1.1 Preparation of specimens for determining the mechanical properties of a material.				
S1.2 Reading and analysis of mechanical properties of material from graphs or table.				
S1.3 Selection of material for mechanical requirements.				

#### Metode poučevanja in učenja:

<ol style="list-style-type: none"><li>1. P1 – avditorna predavanja</li><li>2. P2 – obravnava snovi po urejeni in v naprej razloženi sistematiki</li><li>3. P3 – avditorne in laboratorijske vaje</li><li>4. P5 – uporaba študijskega gradiva v obliki knjig, zapiskov predavanj – tiskana oblika, e-zapiski predavanj.</li></ol>	<p><b>Conventional teaching methods:</b></p> <p>P1 Auditorial lectures.</p> <table border="1"><tr><td>P2 Treats substances according to an orderly and systematic explanation</td></tr></table> <p>P3 Auditorial and laboratory exercises.</p> <p>P5 Application of study material (textbook, e-book, printed lecture presentations).</p>	P2 Treats substances according to an orderly and systematic explanation
P2 Treats substances according to an orderly and systematic explanation		

#### Načini ocenjevanja:

#### Delež/Weight

#### Assessment:

- Teoretične vsebine (predavanja).	50,00 %	- Theoretical content (lectures).
- Delo na vajah (vključno s poročili).	50,00 %	- Laboratory work (including reports).

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

ROMAN ŠTURM:

1. **ŠTURM, Roman**, ŠTEFÁNIKOVÁ, Mária, STEINER PETROVIČ, Darja. Influence of pre-heating on the surface modification of powder-metallurgy processed cold-work tool steel during laser surface melting. Applied Surface Science, ISSN 0169-4332. [Print ed.], Jan. 2015, vol. 325, str. 203-210, ilustr., doi: [10.1016/j.apsusc.2014.11.050](https://doi.org/10.1016/j.apsusc.2014.11.050). [COBISS.SI-ID [13845275](#)]
2. SUŠNIK, Janez, **ŠTURM, Roman**, GRUM, Janez. Influence of laser surface remelting on Al-Si alloy properties. Strojniški vestnik, ISSN 0039-2480, okt. 2012, vol. 58, no. 10, str. 614-620,
3. STEINER PETROVIČ, Darja, **ŠTURM, Roman**, PEPELNJAK, Tomaž. Characterization of macroscopic mechanical anisotropy of magnetocaloric gadolinium cylinders. JOM : The journal of minerals, metals and materials society. 2019, vol. 71, no. 9, str. 3151-3158, ilustr. ISSN 1047-4838., [COBISS.SI-ID [1509034](#)],
4. MARKEŽIČ, Rok, MOLE, Nikolaj, NAGLIČ, Iztok, MARKOLI, Boštjan, **ŠTURM, Roman**. Tool hardness change prediction during high pressure die casting process. V: KRIŽMAN, Alojz (ur.). Conference proceedings = Zbornik referatov. Ljubljana: Slovenian Foundrymen Society, 2019. Str. 1-7.
5. BABIČ, Matej, SKALA, Karolj, KUMAR, Dookhitram, **ŠTURM, Roman**. New hybrid system of machine learning and statistical pattern recognition for a 3D visibility network. Strojniški vestnik. June 2018, vol. 64, no. 6, str. 393-400.