UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Osnove fizike materialov
Course title:	Fundamentals of Physics of Materials

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Nanoznanosti in nanotehnologije, 2. stopnja	/	1	1
Nanosciences and nanotechnologijes, 2nd cycle	/	1	1

Vrsta predmeta / Course type	Obvezni / Mandatory
Univerzitetna koda predmeta / University course code:	NANO2-265

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje work	Druge oblike študija	Samost. delo Individ. work	ECTS
30	30			30	210	**10**

Nosilec predmeta / Lecturer:	Prof. dr. Zdravko Kutnjak Prof. dr. Boštjan Zalar

Jeziki / Languages:	**Predavanja / Lectures:**	slovenski, angleški Slovenian, English
	Vaje / Tutorial:	

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Zaključen študij prve stopnje s področja naravoslovja ali tehnike ali zaključen študij prve stopnje na drugih področjih z znanjem osnov s področja predmeta.	Completed first cycle studies in natural sciences or engineering or completed first cycle studies in other fields with knowledge of fundamentals in the field of this course.

Vsebina:	**Content (Syllabus outline):**
1. Struktura kondenzirane snovi a) Trdne in mehke snovi b) Pojem simetrije in zlom simetrije c) Parameter reda in korelacijske funkcije d) Interakcije med gradniki snovi e) Energije in potenciali f) Tekoče, vmesne in kristalne faze g) Nesoizmerljive strukture h) Kvazikristali 2. Termodinamika in statistična mehanika a) Trije zakoni termodinamike b) Termodinamski potenciali c) Pojem faznega prostora d) Enačba stanja 3. Simetrije v kristalih a) Translacijske in rotacijske simetrije; prostorske	1. Structure of condensed matter systems a) Solid and soft systems b) Concept of symmetry and broken symmetries c) Order parameter and correlation functions d) Particle interactions e) Energies and potentials f) Liquid, mesomorphic and crystal phases g) Incommensurate structures h) Quasicrystals 2. Thermodynamics and statistical mechanics a) The three laws of thermodynamics b) Thermodynamic potentials c) Concept of phase space d) Equation of state 3. Symmetries in crystals a) Translational and rotational symmetries; space

grupe b) Recipročna mreža c) Dimenzionalnost parametra reda in dimenzionalnost sistema 4. Teorija sipanja a) Braggov in Lauejev sipalni pogoj b) Sipanje fotonov, elektronov in nevtronov c) Fourierova transformacija 5. Elektroni in fononi v kristalih a) Kvantna mehanika prostih elektronov b) Periodične funkcije in elektron v periodičnem potencialu c) Harmonska nihanja kristalne mreže d) Fermioni in bozoni e) Električno prevajanje f) Specifična toplota kristalne mreže 6. Elastične lastnosti a) Napetost in deformacija b) Izotropne in kubične snovi c) Razširjanje zvoka 7. Magnetizem a) Magnetni dipolni moment in magnetizacija b) Paramagnetizem in diamagnetizem c) Inducirana in spontana magnetizacija d) Teorija povprečnega polja in Isingov model e) Domene in histereza f) Landau-ova prosta energija g) Kritični pojavi in teorija skaliranja 8. Superprevodnost a) Fenomenološka teorija b) Termodinamika superprevodnikov c) Josephsonov pojav 9. Dislokacije v trdnih snoveh a) Topološke značilnosti b) Vrzeli in intersticijske nečistoče c) Difuzija točkastih defektov d) Martenzitske transformacije 10. Tekočine a) Izotropne in anizotropne tekočine b) Viskoznost c) Navier-Stokes–ova enačba d) Laminarni in turbulentni tok e) Binarne tekočine in fazna separacija f) Koloidi in raztopine	groups b) The reciprocal lattice c) Dimensionality of order parameter and dimensionality of material 4. Scattering theory a) Bragg and Laue scattering conditions b) Scattering of phonons, electrons and neutrons c) Fourier transformation 5. Electrons and phonons in crystals a) Quantum mechanics of free electrons b) Periodic functions and electrons in periodic potentials c) Harmonic lattice vibrations d) Fermions and bosons e) Electrical conduction properties f) Specific heat of a crystal lattice 6. Elastic properties a) Stress and strain b) Isotropic and cubic solids c) Propagation of sound 7. Magnetism a) Magnetic dipole moment and magnetization b) Paramagnetism and diamagnetism c) Induced vs. spontaneous magnetization d) Mean field theory and the Ising model e) Domains and hysteresis f) Landau free energy g) Critical phenomena and scaling theory 8. Superconductivity a) Phenomenological theory b) Thermodynamics of superconductors c) Josephson effect 9. Dislocations in solids a) Topological characteristics b) Vacancies and interstitials c) Diffusion of point defects d) Martensitic transformations 10. Fluids a) Isotropic and anisotropic fluids b) Viscosity c) Navier-Stokes equation d) Laminar and turbulent flow e) Binary fluids and phase separation f) Colloids and solutions

11. Polimeri in tekoči kristali a) Idealna in Flory-jeva veriga b) Entropična elastičnost c) Nematski in smektični red d) Maier-Saupe-jeva teorija 12. Površine a) Površinska napetost b) Adsorbcija in omakanje	11. Polymers and liquid crystals a) Ideal and Flory chains b) Entropic elasticity c) Nematic and smectic order d) Maier-Saupe theory 12. Surface phenomena a) Surface tension b) Adsorption and wetting

Temeljni literatura in viri / Readings:

1. Zapiski predavanj / Lecture notes;
2. Neil W. Ashcroft, N. David Mermin, “Solid State Physics” (Saunders College, Philadelphia, 1987);
3. Maurice Kleman, Oleg D. Lavrentovich, “Soft Matter Physics” (Springer-Verlag, New York, 2003);
4. Gert Strobl, “Condensed Matter Physics” (Springer-Verlag, New York, 2004);5. P. M. Chaikin, T. C. Lubensky, “Principles of Condensed Matter Physics” (Cambridge University Press, Cambridge, 1995);
5. Solid State Physics, J. R. Hook in H. E. Hall, The Manchester Physics Series, John Wiley&Sons (1991).

Cilji in kompetence:	**Objectives and competences:**
Cilj predmeta je spoznavanje področja fizike materialov.	The goal of this course is to give an overview of the field of physics of materials.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Študent se seznani s širokim obsegom pojavov v fiziki kondenzirane materije s ciljem pridobitve osnovnega znanja, s pomočjo katerega bo lahko razvil spretnosti, ki so potrebne pri načrtovanju novih naprednih materialov ter funkcionalnih mikro- in nanostruktur: • razumevanje recipročne mreže • poznavanje teorije sipanja • razumevanje obnašanja elektronov in fononov v kristalih • računanje količin ob faznih prehodih • poznavanje pojavov v mehkih snoveh • obvladovanje pojavov v nanosnoveh • sodelovanje, delo v skupini (in v mednarodnem okolju) • obvladovanje tujega jezika (angleščina) in angleške strokovne literatura	Students are expected to become familiar with a broad range of phenomena in condensed matter physics with the goal of establishing a systematic basis for the development of skills for engineering new advanced materials and functional micro- and nanostructures: • understanding concepts of reciprocal lattice • knowledge about scattering theory • understanding of electron and phonon properties of crystals • computation of phase transition properties • knowledge about soft matter properties • mastering of various effects in nanomaterials • cooperation, group work and in international environment • mastering foreign language (English) and english professional literature

Metode poučevanja in učenja:	**Learning and teaching methods:**
Interaktivna predavanja Seminar, konzultacije Individualno voden študij	Interactive lectures Seminar, consultations Individual guided studies

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Pisni izpit	50 %	Written exam
Ustni izpit	50 %	Oral examination

Reference nosilca / Lecturer's references:

KUTNJAK, Zdravko, PETZELT, Jan, BLINC, Robert. The giant electromechanical response in ferroelectric relaxors as a critical phenomenon. *Nature*, ISSN 0028-0836, 2006, vol. 441, str. 956-959.

LEBAR, Andrija, CORDOYIANNIS, George, KUTNJAK, Zdravko, ZALAR, Boštjan. The isotropic-to-nematic conversion in liquid crystalline elastomers. *Advances in polymer science*, ISSN 0065-3195, 2012, vol. 250, str. 147-185, doi: 10.1007/12_2010_103.

PIRC, Raša, ROŽIČ, Brigita, KORUZA, Jurij, MALIČ, Barbara, KUTNJAK, Zdravko. Negative electrocaloric effect in antiferroelectric PbZrO[sub]3. *Europhysics letters*, ISSN 0295-5075, 2014, vol. 107, no. 1, str. 17002-1-17002-5, doi: 10.1209/0295-5075/107/17002.

PIRC, Raša, KUTNJAK, Zdravko. Electric-field dependent freezing in relaxor ferroelectrics = R. Pirc and Z. Kutnjak. *Physical review. B, Condensed matter and materials physics*, ISSN 1098-0121, 2014, vol. 89, no. 18, str. 184110-1-184110-7, doi: 10.1103/PhysRevB.89.184110.

KUTNJAK, Zdravko, PIRC, Raša. Specific heat anomaly in relaxor ferroelectrics and dipolar glasses. *Journal of Applied Physics*, ISSN 0021-8979, 2017, vol. 121, no. 10, str. 105107-1-105107-7.