UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Teorija kondenzirane snovi
Course title:	Condensed Matter Theory

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

Vrsta predmeta / Course type Izbirni / Elective

Univerzitetna koda predmeta / University course code: NANO2-267

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

**Navedena porazdelitev ur velja, če je vpisanih vsaj 15 študentov. Drugače se obseg izvedbe kontaktnih ur sorazmerno zmanjša in prenese v samostojno delo. / This distribution of hours is valid if at least 15 students are enrolled. Otherwise the contact hours are linearly reduced and transfered to individual work.*

Nosilec predmeta / Lecturer: Prof. dr. Viktor Kabanov

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 cycle level studies in other fields with knowledge of fundamentals in the field of this course.

Vsebina:	**Content (Syllabus outline):**
1. Uvod. 2. Osnove teorije grup: Ireducibilne upodobitve. 3. Nihanja v kristalnih rešetkah. Klasifikacija nihanj. 4. Elektroni v kristalu: približek tesne vezi in približek šibke sklopitve. 5. Teorija gostotnega funkcionala za opis elektronske strukture. 6. Različni tipi kristalov: kovalentni, molekulski in ionski kristali, kristali na podlagi vodikove vezi in kovine. 7. Lokalizirani elektroni v kristalu: eksitoni in polaroni. 8. Termodinamske lastnosti trdnih snovi. 9. Magnetne lastnosti: Paulijev paramagnetizem, Landau-ov diamagnetizem. Kvantni efekti.	1. Introduction. 2. Elements of group theory. Irreducible representations. 3. Lattice vibrations in crystalline solids. Mode classifications. 4. Electrons in crystals. Tight-binding and weak coupling approximations. 5. Density-Functional-Theory: a practical first-principle method for the calculation of electronic structure. 6. Classification of solids: covalent, molecular, ionic, H-bonded crystals and metals. 7. Localized electrons in solids. Excitons. Polarons. 8. Thermodynamic properties of solids. 9. Magnetic properties. Pauli paramagnetizm,

10. Optične lastnosti trdnih snovi. Dielektrična funkcija. 11. Kinetične lastnosti kovin in polprevodnikov. Kinetična enačba. 12. Pojav sipanja. Sipanje nečistoč, fononsko sipanje. 13. Kinetični procesi v magnetnem polju. Hallov efekt in magnetoupornost. 14. Teorija faznih prehodov. Isingov model, Landau-ova teorija faznih prehodov. Kinetika faznih prehodov. 15. Superprevodnost. Cooperjevi pari. Ginzburg-Landau-ova teorija. Kritični tok in kritično polje. Kvantni efekti. 16. Strukture nižjih dimenzij: površine in molekule ter njihova interakcija – heterogena kataliza.	Landau diamagnetism. Quantum effects. 10. Optical properties of solids. Dielectric function. 11. Kinetic properties of metals and semiconductors. Kinetic equation. 12. Scattering processes. Impurity scattering, scattering by phonons. 13. Kinetic processes in magnetic field. Hall effect, magnetoresistance. 14. Theory of phase transition. Ising model, Landau theory of phase transition. Kinetics of phase transitions. 15. Superconductivity. Cooper pairs. Ginzburg-Landau theory. Critical current and critical field. Quantum effects. 16. From 3D to lower dimensions: surfaces, molecules, and heterogeneous catalysis.

Temeljni literatura in viri / Readings:

N.W. Ashcroft N.D. Mermin, Solid State Physics, Holt-Saunders, 1976.
A.A. Abrikosov, Fundamentals of the theory of metals, North-Holland, 1988.
P.G. de Gennes, Superconductivity of Metals and Alloys, Perseus books, 1999.
L.D. Landau and E.M. Lifshitz, Statistical Physics, Pergamon Press, 2005.
E.M. Lifshitz and L.P. Pitaevskii, Statistical Physics, Pergamon Press, 2002.
Charles Kittel, Introduction to Solid State, J. Wiley, 2005.
R.M. Martin, Electronic structure: basic theory and practical methods, Cambridge University Press, 2004.

Cilji in kompetence:	**Objectives and competences:**
Cilj predmeta je spoznavanje aktualnih problemov in najnovejših dosežkov na področju teorije nanomaterialov.	The goal of this course is to give an overview of the major directions of research and the latest achievements in the field of theory of nanomaterials.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Študentje bodo dobili pregled o teoretičnih metodah za študij fizike trdnih snovi. Pri tem bodo pridobili osnovno razumevanje elektronske teorije, teorije pasov, električnih, magnetnih in superprevodnih lastnostih materialov in nanomaterialov. Seznanili se bodo s popularno metodo za izračun elektronske strukture trdnih snovi, t.j. teorijo gostotnega funkcionala.	Students will gain an overview of theoretical techniques for studying physics of solid state. They will gain a basic understanding of theory of electron systems, band theory and electrical, magnetic and superconducting properties of materials and nanomaterials. They will learn the fundamentals of density-functional-theory: a first principles method for the calculation of the electronic structure of solids.

Metode poučevanja in učenja:	**Learning and teaching methods:**
• Predavanja • Seminarji • Konzultacije • Laboratorijsko del	• Lectures • Seminar work • Consultations • Laboratory work

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

Reference nosilca / Lecturer's references:

SHUMILIN, A. V., KABANOV, Viktor V., DEDIU, V. I. Magnetoresistance in organic semiconductors : including pair correlations in the kinetic equations for hopping transport. *Physical review. B*, ISSN 2469-9950, 2018, vol. 97, no. 9, str. 094201-1-094201-9, doi: 10.1103/PhysRevB.97.094201

BUH, Jože, MRZEL, Aleš, KOVIČ, Andrej, KABANOV, Viktor V., JAGLIČIĆ, Zvonko, VRTNIK, Stanislav, KOŽELJ, Primož, MIHAILOVIĆ, Dragan. Phase slip and telegraph noise in δ−MoNδ−MoN nanowires. *Physica. C, Superconductivity and its applications*, ISSN 0921-4534. [Print ed.], 2017, vol. 535, str. 24-29, doi: 10.1016/j.physc.2017.03.003

BECK, M., KABANOV, Viktor V., DEMŠAR, Jure, et al. Energy dependence of the electron-boson coupling strength in the electron-doped cuprate superconductor Pr[sub](1.85)Ce[sub](0.15)CuO[sub](4-[delta]). *Physical review. B*, ISSN 2469-9950, 2017, vol. 95, no. 8, str. 085106-1-085106-8, doi: 10.1103/PhysRevB.95.085106

MADAN, Ivan, BARANOV, Vladimir V., TODA, Y., ODA, Migaku, KUROSAWA, T., KABANOV, Viktor V., MERTELJ, Tomaž, MIHAILOVIĆ, Dragan. Dynamics of superconducting order parameter through ultrafast normal-to-superconducting phase transition in Bi2Sr2CaCu2O8+δBi2Sr2CaCu2O8+δ from multipulse polarization-resolved transient optical reflectivity. *Physical review. B*, ISSN 2469-9950, 2017, vol. 96, no. 18, str. 184522-1- 184522-9, doi: 10.1103/PhysRevB.96.184522

BUH, Jože, KABANOV, Viktor V., BARANOV, Vladimir V., MRZEL, Aleš, KOVIČ, Andrej, MIHAILOVIĆ, Dragan. Control of switching between metastable superconducting states in δδ-MoN nanowires. *Nature communications*, ISSN 2041-1723, 2015, vol. 6, str. 10250-1-10250-6, doi: 10.1038/ncomms10250