



Fakulteta za naravoslovje  
in matematiko

### UČNI NAČRT PREDMETA / COURSE SYLLABUS

<b>Predmet:</b>	<b>Fizikalne lastnosti materialov</b>
<b>Course title:</b>	<b>Physical Properties of Materials</b>

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
FIZIKA, 3. stopnja		1. ali 2.	1., 2. ali 4.
PHYSICS, 3 <sup>rd</sup> cycle		1. or 2.	1., 2. or 4.

Vrsta predmeta / Course type

Izbirni za vse module

Univerzitetna koda predmeta / University course code:

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Lab. vaje Laboratory work	Terenske vaje Field work	Samost. delo Individ. work	ECTS
15					165	6

Nosilec predmeta / Lecturer:

Zdravko Kutnjak

Jeziki /

Languages:

Predavanja /

Lectures:

slovenski/Slovenian

Vaje / Tutorial:

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

Ni pogojev.

Priporočljivo je predznanje iz moderne fizike

**Prerequisites:**

None.

Recommended is basic knowledge of modern physics

**Vsebina:**

- 1) struktura materialov in interakcije
- 2) Elektroni v kristalih: fermijeva površina, gostota stanj, energijski pasovi, prevodni pas

**Content (Syllabus outline):**

- 1) Structure of materials: building blocks and interactions,
- 2) Theory of electrons in crystals: free electrons, energy levels/bands, Fermi surface, density of states

<p>3) Polprevodniki: homogeni, cisti in dopirani, prevodne lastnosti, nehomogeni, p-n stik, p-n-p tranzistor</p> <p>4) Mrežna nihanja: veriga atomov, optična in akustična veja, fononi, toplotna kapaciteta</p> <p>5) Mrežni defekti in efekti končnih dimenzij</p> <p>6) Dielektriki in Feroelektriki: dielektričnost, spontana polarizacija</p> <p>7) Magnetne lastnosti, diamagneti, paramagneti, feromagneti, magnoni</p> <p>8) Fazni prehodi: Landauova fenomenološka teorija, naivna teorija povprečnega polja, neklasični primeri, univerzalnostni razredi</p> <p>9) superprevodniki, osnovne lastnosti, Londonova fenomenološka teorija, Cooperjevi pari, visokotemperaturni superprevodniki</p> <p>10) Uvod v lastnosti mehke snovi: polimeri, tekoči kristali, koloidi</p>	<p>3) Semiconductors: pure and doped, transport properties, p-n junction, laser diodes, p-n-p transistor,</p> <p>4) Lattice vibrations: chain of atoms, optical and acoustic branch, phonons, specific heat</p> <p>5) Defects of crystal lattice and finite-size effects</p> <p>6) Dielectrics and ferroelectrics: dielectric constant, spontaneous polarization</p> <p>7) Magnetic properties: diamagnets, paramagnets, ferromagnets, magnons</p> <p>8) Phase transitions: Landau phenomenological theory, naive mean-field theory, nonclassical examples, universality classes</p> <p>9) superconductors: basic properties, London theory, Cooper's pairs, high Tc superconductors</p> <p>10) An introduction to soft matter properties: polymers, Liquid crystals, colloids</p>
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#### Temeljni literatura in viri / Readings:

1. Chaikin, P. M., & Lubensky, T. C. (2003). Principles of condensed matter physics. Cambridge: Cambridge University Press. [COBISS.SI-ID 2956058] <https://plus.cobiss.net/cobiss/si/sl/bib/pefmb/2956058>
2. Kittel, C. (1996). Introduction to solid state physics (7th ed.). New Brisbane: Wiley. [COBISS.SI-ID 14037799] <https://plus.cobiss.net/cobiss/si/sl/bib/pefmb/14037799>
3. Kléman, M., & Lavrentovich, O. D. (2003). Soft matter physics: an introduction. New York: Springer. [COBISS.SI-ID 1580644] <https://plus.cobiss.net/cobiss/si/sl/bib/pefmb/1580644>
4. Prelovšek, P. (2000). Teorija trdne snovi: podiplomski študij fizike. Ljubljana: DMFA - založništvo. [COBISS.SI-ID 105689856] <https://plus.cobiss.net/cobiss/si/sl/bib/pefmb/105689856>
5. Strnad, J. (2000). Fizika. Del 4, Molekule, kristali, jedra, delci (2. spremenjena izd.). Ljubljana: DMFA - založništvo. [COBISS.SI-ID 106115584] <https://plus.cobiss.net/cobiss/si/sl/bib/pefmb/106115584>
6. Filipič, C., Canu, G., Pirc, R., Kutnjak, Z. (2023). Glassy properties of the lead-free isovalent relaxor BaZr<sub>0.4</sub>Ti<sub>0.6</sub>O<sub>3</sub>. *Crystals*, 13(9), 1303, 1–12. [COBISS.SI-ID 162375171] <https://www.mdpi.com/2073-4352/13/9/1303>, DOI: 10.3390/cryst13091303.

#### Dodatna literatura / Additional readings:

1. Hofmann, P. (2022). Solid state physics: an introduction. Wiley. [COBISS.SI-ID 223521795]
2. Kutnjak, Z. (2012). Physics of materials: selected problems. Ljubljana: Jožef Stefan International Postgraduate School. [COBISS.SI-ID 25779495]

3. Ravnik, M., & Žumer, S. (2020). Izbrani znanstveni članki s področja tekočih kristalov (mehka snov). [Članki iz znanstvenih revij: Soft Matter, Physical Review E, Liquid Crystals ipd.]
4. Digitalne zbirke Springer, ScienceDirect (UM dostop) – Članki s področja dielektrikov, feroelektrikov, superprevodnosti.

1.

#### Cilji in kompetence:

Izravnalni predmet, ki da določeno predznanje tistim študentom, ki nimajo dovolj predznanja iz fizike kondenzirane materije, tako, da lahko v nadaljnjih semestrih sledijo bolj specializiranim in poglobljenim predmetom.

#### Objectives and competences:

Introductory course, which purpose is to equalize the knowledge of students. It is suitable for those students who did not acquire enough basic knowledge in condensed matter physics. Acquired knowledge within the course should allow them to be able to follow later more specialized courses.

#### Predvideni študijski rezultati:

Znanje in razumevanje:

Poglobljeno razumevanje fizikalnih lastnosti procesov v izbranih snoveh.

Prenosljive/ključne spretnosti in drugi atributi:

Rešitev problemov z matematičnimi orodji, numeričnimi metodami, univerzalnosti v fiziki in celosten pristop k reševanju problemov.

#### Intended learning outcomes:

Knowledge and understanding:

Advanced understanding of physical properties in selected materials.

Transferable/Key Skills and other attributes:

Solving of problems with mathematical tools, numerical methods, universalities in physics and gained global approach on solving a problem.

#### Metode poučevanja in učenja:

Metodika obsega predavanja (razlaga, diskusija) in samostojnega dela v obliki seminarjev, ki podajajo uvod v problematiko in trenutno razumevanja fizikalnih lastnosti materialov (individualizacija poučevanja).

#### Learning and teaching methods:

Lectures (explanation and discussion) and seminars providing the introduction of current knowledge of physical properties of condensed matter materials (individualization in teaching).

#### Načini ocenjevanja:

Način (pisni izpit, ustno izpraševanje, naloge, projekt)

Seminar

Ustni izpit

Seminarska naloga

Ustni izpit

Delež (v %) /

Weight (in %)

#### Assessment:

Type (examination, oral, coursework, project):

Seminar

Oral exam

Seminar paper

Oral exam

60%

40%

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

- FILIPIČ, Cene, CANU, Giovanna, PIRC, Raša, KUTNJAK, Zdravko. Glassy properties of the lead-free isovalent relaxor BaZr<sub>0.4</sub>Ti<sub>0.6</sub>O<sub>3</sub>. Crystals. Sep. 2023, vol. 13, iss. 9, [article no.] 1303, str. 1-12, ilustr. ISSN 2073-4352. <https://www.mdpi.com/2073-4352/13/9/1303>, DOI: 10.3390/cryst13091303. [COBISS.SI-ID 162375171],
- KHARDAZI, Said, ZAITOUNI, H., NEQALI, A., LYUBCHYK, Svitlana, MEZZANE, Daoud, AMJOURD, M'barek, CHOUKRI, El Hassan, LYUBCHYK, Sergiy, KUTNJAK, Zdravko. Enhanced thermal stability of dielectric and energy storage properties in 0.4BCZT-0.6BTSn lead-free ceramics elaborated by sol-gel method. Journal of physics and chemistry of solids. Jun. 2023, vol. 177, [article no.] 111302, str. 1-10, ilustr. ISSN 1879-2553. <https://www.sciencedirect.com/science/article/pii/S0022369723000926?via%3Dihub>, DOI: 10.1016/j.jpics.2023.111302. [COBISS.SI-ID 144412931],
- ZAHID, Marwa, HADOUCH, Youness, AMJOURD, M'barek, MEZZANE, Daoud, GOUNÉ, Mohamed, HOUMMADA, Khalid, ALIMOUSSA, Abdelhadi, RAZUMNAYA, Anna G., ROŽIČ, Brigita, KUTNJAK, Zdravko. Enhanced near-ambient temperature energy storage and electrocaloric effect in the lead-free BaTi<sub>0.89</sub>Sn<sub>0.11</sub>O<sub>3</sub>BaTi<sub>0.89</sub>Sn<sub>0.11</sub>O<sub>3</sub> ceramic synthesized by sol-gel method. Journal of materials science. Materials in electronics. [Print ed.]. [in press] 2022, 12 str., graf. prikazi. ISSN 0957-4522. DOI: 10.1007/s10854-022-08233-6