



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		1. ali 2.	1., 2. ali 4.
PHYSICS		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:**

**Vaje / Tutorial:**

slovenski/Slovenian in/and angleški s slovenskim prevodom/English with translation in Slovenian

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

Predznanje iz moderne fizike

**Prerequisites:**

Basic knowledge of modern physics

**Vsebina:**

- 1) struktura materialov in interakcije
- 2) Elektroni v kristalih: fermijeva površina, gostota stanj, energijski pasovi, prevodni pas
- 3) Polprevodniki: homogeni, cisti in dopirani, prevodne lastnosti, nehomogeni, p-n stik, p-n-p tranzistor

**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
- 3) Semiconductors: pure and doped, transport properties, p-n junction, laser diodes, p-n-p transistor,

4) Mrežna nihanja: veriga atomov, optična in akustična veja, fononi, toplotna kapaciteta

5) Mrežni defekti in efekti končnih dimenzij

6) Dielektriki in Feroelektriki: dielektričnost, spontana polarizacija

7) Magnetne lastnosti, diamagneti, paramagneti, feromagneti, magnoni

8) Fazni prehodi: Landauova fenomenološka teorija, naivna teorija povprečnega polja, nekласični primeri, univerzalnostni razredi

9) superprevodniki, osnovne lastnosti, Londonova fenomenološka teorija, Cooperjevi pari, visokotemperaturni superprevodniki

10) Uvod v lastnosti mehke snovi: polimeri, tekoči kristali, koloidi

4) Lattice vibrations: chain of atoms, optical and acoustic branch, phonons, specific heat

5) Defects of crystal lattice and finite-size effects

6) Dielectrics and ferroelectrics: dielectric constant, spontaneous polarization

7) Magnetic properties: diamagnets, paramagnets, ferromagnets, magnons

8) Phase transitions: Landau phenomenological theory, naive mean-field theory, nonclassical examples, universality classes

9) superconductors: basic properties, London theory, Cooper's pairs, high T<sub>c</sub> superconductors

10) An introduction to soft matter properties: polymers, Liquid crystals, colloids

#### Temeljni literatura in viri / Readings:

- 1) *Physics of Materials*, Yves Quere, Gordon and Beach Science Publishers (1998);
- 2) *Introduction to Solid State Physics*, C. Kittel, John Willey, 1986
- 3) *Teorija trdne snovi*, P. Prelovšek, Ljubljana, 1999
- 4) *Solid State Physics*, N.W. Ashcroft, Rinehart & Winston, 1976
- 5) *Molekule, kristali, jedra, delci*, J. Strnad, DZS, 1982 (slovenian)
- 6) M. Klemm, O.D. Lavrentovich, *Soft Matter Physics*, Springer-Verlag, New York, 2003.
- 7) P. M. Chaikin, T. C. Lubensky, *Principles of Condensed Matter Physics*, Cambridge University Press, Cambridge, England, 1995.
- 8) Clanki v Science, Nature, Scientific American.
- 9) *Soft Matter Physics*, M. Daoud, Springer, 1999

#### 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:

#### Intended learning outcomes:

<p>Znanje in razumevanje:</p> <p>Razumevanje fizikalnih lastnosti procesov v izbranih snoveh.</p> <p>Prenosljive/ključne spretnosti in drugi atributi:</p> <p>Rešitev problemov z matematičnimi orodji, numeričnimi metodami, univerzalnosti v fiziki in celosten pristop k reševanju problemov.</p>	<p>Knowledge and understanding:</p> <p>Understanding of physical properties in selected materials.</p> <p>Transferable/Key Skills and other attributes:</p> <p>Solving of problems with mathematical tools, numerical methods, universalities in physics and gained global approach on solving a problem.</p>
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<p><b>Metode poučevanja in učenja:</b></p> <p>Metodika obsega predavanja in samostojnega dela v obliki seminarjev, ki podajajo uvod v problematiko in trenutno razumevanja fizikalnih lastnosti materialov.</p>	<p><b>Learning and teaching methods:</b></p> <p>Lectures and seminars providing the introduction of current knowledge of physical properties of condensed matter materials</p>
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<b>Načini ocenjevanja:</b>	Delež (v %) / Weight (in %)	<b>Assessment:</b>
Način (pisni izpit, ustno izpraševanje, naloge, projekt)		Type (examination, oral, coursework, project):
Seminar	<b>60%</b>	Seminar
Ustni izpit	<b>40%</b>	Oral exam

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

1. 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, doi: [10.1063/1.4978249](https://doi.org/10.1063/1.4978249). [COBISS.SI-ID [30332199](#)]
2. TRČEK, Maja, CORDOYIANNIS, George, ROŽIČ, Brigita, TZITZIOS, Vassilios, NOUNESIS, George, KRALJ, Samo, LELIDIS, Ioannis, LACAZE, Emmanuelle, AMENITSCH, Heintz, KUTNJAK, Zdravko. Twist-grain boundary phase induced by Au nanoparticles in a chiral liquid crystal host. *Liquid crystals*, ISSN 0267-8292, 2017, 7 str., doi: [10.1080/02678292.2017.1306887](https://doi.org/10.1080/02678292.2017.1306887). [COBISS.SI-ID [30373159](#)]
3. TRČEK, Maja, LAVRIČ, Marta, CORDOYIANNIS, George, ZALAR, Boštjan, ROŽIČ, Brigita, KRALJ, Samo, TZITZIOS, Vassilios, NOUNESIS, George, KUTNJAK, Zdravko. Electrocaloric and elastocaloric effects in soft materials. *Philosophical transactions, Mathematical, physical and engineering sciences*, ISSN 1364-503X. [Print ed.], [in press] 2016, 11 str., doi: [10.1098/rsta.2015.0301](https://doi.org/10.1098/rsta.2015.0301). [COBISS.SI-ID [29634343](#)]
4. URŠIČ, Hana, BOBNAR, Vid, MALIČ, Barbara, FILIPIČ, Cene, VRABELJ, Marko, DRNOVŠEK, Silvo, YOUNGHUN, Jo., WENCKA, Magdalena, KUTNJAK, Zdravko. A multicaloric material as a link between electrocaloric and magnetocaloric refrigeration. *Scientific reports*, ISSN 2045-2322, 2016, vol. 6, str. 26629-1-26629-5, doi: [10.1038/srep26629](https://doi.org/10.1038/srep26629). [COBISS.SI-ID [29513767](#)]
5. PLAZNIK, Uroš, KITANOVSKI, Andrej, ROŽIČ, Brigita, MALIČ, Barbara, URŠIČ, Hana, DRNOVŠEK, Silvo, CILENŠEK, Jena, VRABELJ, Marko, POREDOŠ, Alojz, KUTNJAK, Zdravko. Bulk relaxor

ferroelectric ceramics as a working body for an electrocaloric cooling device. *Applied physics letters*, ISSN 0003-6951. [Print ed.], 2015, vol. 106, nr. 4, str. 1-4, ilustr., doi: [10.1063/1.4907258](https://doi.org/10.1063/1.4907258). [COBISS.SI-ID [13878299](#)]