



Fakulteta za naravoslovje
in matematiko

UČNI NAČRT PREDMETA / COURSE SYLLABUS

Predmet:	Fizikalne lastnosti materialov
Course title:	Physical Properties of Materials

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 rd 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

3) Polprevodniki: homogeni, cisti in dopirani, prevodne lastnosti, nehomogeni, p-n stik, p-n-p tranzistor

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, neklasični primeri, univerzalnostni razredi

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

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

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

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 Tc 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. Kleman, 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:

Znanje in razumevanje:

Poglobljeno razumevanje fizikalnih lastnosti procesov v izbranih snoveh.

Prenesljive/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

Delež (v %) /

Weight (in %)

Assessment:

Type (examination, oral, coursework, project):

Seminar

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](https://www.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](https://www.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](https://www.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](https://www.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](https://www.cobiss.si/id/13878299)]