UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Fizika nanomaterialov
Course title:	Physics of Nanomaterialov

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Nanoznanosti in nanotehnologije, 3. stopnja	-	1	1
Nanosciences and Nanotechnologijes, 3rd cycle	-	1	1

Vrsta predmeta / Course type	Izbirni / Elective
Univerzitetna koda predmeta / University course code:	NANO3-799

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. Dragan Mihailović Prof. dr. Christoph Gadermaier

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

Pogoji za vključitev v delo:	**Prerequisits:**
Zaključena izobrazba druge stopnje ali univerzitetna izobrazba s področja naravoslovja ali tehnologije.	Completed masters level education or equivalent university education from natural sciences or technology.

Vsebina:	**Content (Syllabus outline):**
Predmet podaja pregled fizike nanomaterialov - nanocevčic, kvantnih pik, tankih plasti, nanomagnetov, fulerenov, nizkodimenzionalnih materialov, faznih prehodov v nanomaterialih ipd., skupaj z eksperimentalnimi metodami, ki so bile razvite za proučevanje nanomaterialov, kot so mikroskopija na elektronsko silo, presevna elektronska mikroskopija, optična spektroskopija nanomaterialov in druge. Simetrija, kvantna števila in izbirna pravila.	Overview of modern physics concepts in the theory of nanomaterials, with emphasis on low-dimensional systems, the theory of phase transitions in disordered substances, e.g. in spin glasses, relaxors and nanomagnets. Carbon and inorganic nanotubes. Symmetry, quantum numbers and selection rules, Experimental methods for the study of the properties of nanomaterials, such as different microscopies, optical spectroscopy, tunneling spectroscopy and scanning probe microscopy.

Temeljni literatura in viri / Readings:

Temeljni študijski viri so objavljeni članki v zadnjih letih, predvsem v revijah Science, Nature in Physical Review Letters, Nano Letters, Nature Nanotechnology, Nature Physics ter pregledni članki.
The main sources are review articles as wells as chosen articles in Science, Nature in Physical Review Letters, Nano Letters, Nature Nanotechnology, Nature Physics and similar journals.

Introductory texts: C.Kittel "**Introduction to Solid State Physics**", 8th edition (Wiley 2005), particularly chapters on nantotechnology and nanomaterials (18 and 19).

Nanomagnetism: Applications and Perspectives
Claude Fermon (Editor), Marcel Van de Voorde (Editor) ISBN: 978-3-527-33985-3 (2017) or equivalent.

Science of Fullerenes and Carbon Nanotubes by M. S. Dresselhaus (Editor), G. Dresselhaus (Editor), P. C. Eklund (Editor) Academic Press; ISBN: 0122218205; (1996)
Nanoelectronics and information technology, Reiner Waser (Ed.) (Wiley, 2005)

Cilji in kompetence:

Študenti spoznajo najnovejše dosežke v fiziki nanomaterialov in se pripravijo za raziskovalno delo na področju fizike nanomaterialov. Hkrati je podana primerjava fizikalnih lastnosti nanomaterialov z lastnostmi periodičnih kristalov in amorfnih praškov.

Splošne kompetence:

- obvladanje raziskovalnih metod za obravnavo fizike nanomaterialov,
- sposobnost uporabe fizikalnega znanja v nanomaterialih,
- razvoj komunikacijskih sposobnosti in spretnosti, posebej komunikacije v mednarodnem okolju,
- kooperativnost, delo v skupini (in v mednarodnem okolju)

Predmetnospecifične kompetence:
Predmet pripravlja študente za uporabo znanja s področja fizike nanomaterialov.

Objectives and competences:

Students will become acquainted with the latest advances in nanomaterials, and prepare themselves for research work in the field of nanomaterials.

General Competences:

- The student will master research methods in the physics of nanomaterials
- The student will develop a proficiency in using physics specific to nanomaterials systems
- The student will develop communications skills to present research achievement in the international environment
- Work in team (in international environment)

Course Specific Competences:
This course prepares students to apply knowledge of the physics of nanomaterials.

Predvideni študijski rezultati:

Funkcionalno znanje področja, skozi poglobljen študij izbranih primerov iz fizike nanomaterialov, prirejenih raziskovalnemu programu študenta.

Študenti obvladajo najnovejše dosežke v fiziki nanomaterialov in nanosistemov kot temelj za raziskovalno delo na področju fizike nanomaterialov, nanotehnologije in nanoelektronike. Študenti bodo obvladovali: fiziko nizkodimenzionalnih sistemov, fiziko omejenih sistemov, fiziko nanostruktur,

Intended learning outcomes:

A functional knowledge of the field, through in-depth study of selected examples in the physics of nanomaterials specially adapted to the research topic of the student.

Students will master the latest advances in nanomaterials and nanosystems and nanoelectronics. They will become proficient in the physics in low-dimensional systems, physics of confined structures, physics of nanostructures, fundamentals of measurements in low dimensional

osnove meritev nizkodimenzionalnih sistemov. Študenti se bodo seznanili tudi s primeri uporabe fizikalnih pojavov v nanotehnologiji.	systems. Students will also learn about a number of examples of the use of nanophysical phenomena leading to applications in nanotechnology.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Interaktivna predavanja Seminar Laboratorijsko delo Individualno voden študij	Interactive lectures Seminar Laboratory work Individual guided studies

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

Reference nosilca / Lecturer's references:

- STOJCHEVSKA, Ljupka, VASKIVSKYI, Igor, MERTELJ, Tomaž, KUŠAR, Primož, SVETIN, Damjan, BRAZOVSKII, Serguei, MIHAILOVIĆ, Dragan. Ultrafast switching to a stable hidden quantum state in an electronic crystal. *Science*, ISSN 0036-8075, 2014, vol. 344, no. 6180, str. 177-180, doi: 10.1126/science.1241591.
- MADAN, Ivan, KUROSAWA, T., TODA, Y., ODA, Migaku, MERTELJ, Tomaž, KUŠAR, Primož, MIHAILOVIĆ, Dragan. Separating pairing from quantum phase coherence dynamics above the superconducting transition by femtosecond spectroscopy. *Scientific reports*, ISSN 2045-2322, 2014, vol. 4, str. 05656-1-05656-5. http://www.nature.com/srep/2014/140711/srep05656/pdf/srep05656.pdf, doi: 10.1038/srep05656.
- NARYMBETOV, Bakhyt, OMERZU, Aleš, KABANOV, Viktor V., TOKUMOTO, Madoka, KOBAYASHI, Hayato, MIHAILOVIĆ, Dragan. Origin of ferromagnetic exchange interactions in a fullerene-organic compound. *Nature*, ISSN 0028-0836, 2000, vol. 407, str. 883-885.
- YUSUPOV, Roman V., MERTELJ, Tomaž, KABANOV, Viktor V., BRAZOVSKII, Serguei, KUŠAR, Primož, CHU, Jiun-Haw, FISHER, Ian R., MIHAILOVIĆ, Dragan. Coherent dynamics of macroscopic electronic order through a symmetry breaking transition. *Nature physics*, ISSN 1745-2473, 2010, vol. 6, no. 9, str. 681-684.
- REMŠKAR, Maja, MRZEL, Aleš, ŠKRABA, Zora, JESIH, Adolf, ČEH, Miran, DEMŠAR, Jure, SADELMANN, Pierre, LÉVY, Francis, MIHAILOVIĆ, Dragan. Self-assembly of subnanometer-diameter single-wall MoS[sub]2 nanotubes. *Science*, ISSN 0036-8075, 2001, vol. 292, str. 479-481.