

UČNI NAČRT PREDMETA / COURSE SYLLABUS

Predmet:	Modelska fizika
Course title:	Modelling Physics

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Fizika 2. st.		1	1
Physics 2 nd degree		1	1

Vrsta predmeta / Course type

Univerzitetna koda predmeta / University course code:

Predavanja Lectures	Seminar Seminar	Sem. vaje Tutorial	Lab. vaje Laboratory work	Teren. vaje Field work	Samost. delo Individ. work	ECTS
30	0	30	30	0	180	9

Nosilec predmeta / Lecturer:

Jeziki / Languages:	Predavanja / Lectures:	slovenski/Slovenian in/and angleški/English
	Vaje / Tutorial:	slovenski/Slovenian in/and angleški/English

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

Ni zahtev. Priporočeno znanje iz osnov klasične fizike, programiranja in matematične fizike.

Vsaka obveznost študenta v načinih ocenjevanja mora biti opravljena s pozitivno oceno. Opravljene sprotne naloge in seminarska naloga so pogoji za pristop k ustnemu izpitu.

Prerequisites:

None. Recommended basic knowledge of classical physics, programming and mathematical physics.

Each student requirement within the assessment methods must be completed with a passing grade. Completed coursework and seminar paper are a prerequisite for taking the oral exam.

Vsebina:

- **Univerzalni numerični modelni sistemi**
- **Grafični prikaz podatkov:** obdelava s programskimi orodji
- **Naključni sprehajalec:** pokrajinsko in koračno pravilo, evolucijski modeli, aplikacije v živi in neživi naravi
- **Celični avtomati:** modeliranje samo-organizirano kritičnih pojavov
- **Nelinearni sistemi:** kaos, fraktali, karakterizacija
- **Univerzalni fenomenološki modeli:** opis modela, ravnovesni pogoji in enačbe, izračun merljivih odzivnih funkcij, kritično obnašanje
- **Metode Monte Carlo:** simulacija pojava, analiza podatkov
- **Metode molekularne dinamike:** simulacija pojava, analiza podatkov
- **Fazni prehodi:** analiza kritičnega obnašanja za izbran primer s programskim orodjem
- **Evolucijsko programiranje:** genetski algoritmi
- **Nevronske mreže:** učna pravila, globoko učenje, konvolucijske nevrnske mreže, veliki jezikovni modeli

Content (Syllabus outline):

- **Universal numerical model systems**
- **Graphical presentation of data:** software tools
- **Random walk:** landscape and step rule, evolution models, applications in nature
- **Cellular automata:** modeling of self-organized critical behavior
- **Non-linear systems:** chaos, fractals, characterization
- **Universal phenomenological models:** description of the model, equilibrium conditions and equations, evaluation of measurable response functions, critical behavior
- **Monte Carlo methods:** simulations and data analysis
- **Molecular dynamics:** simulations and data analysis
- **Phase transitions:** analysis of critical behavior for a given case using a software tool
- **Evolution programming:** genetic algorithms
- **Neural networks:** learning rules, deep learning, convolutional neural networks, large language models

- **Kvantni računalniki:** Shorov algoritem, Groverjev algoritem, BB84, Hadamardova vrata

- **Quantum computers:** Shor algorithm, Grover's algorithm, BB84, Hadamard gate

Temeljni literatura in viri / Readings:

- F. J. Vesely, Computational Physics: An Introduction, Springer, 2012.
- Ian Goodfellow, Yoshua Bengio and Aaron Courville, Deep Learning, The MIT Press, 2016 (dostopno na <https://www.deeplearningbook.org/>).
- C. P. Williams, Explorations in Quantum Computing, Springer, 2010 (dostopno na <https://link.springer.com/book/10.1007/978-1-84628-887-6>).
- C. Bernhardt, [Quantum Computing for Everyone](https://direct.mit.edu/books/book/4186/Quantum-Computing-for-Everyone), The MIT Press, 2019 (dostopno na <https://direct.mit.edu/books/book/4186/Quantum-Computing-for-Everyone>).

Dodatna literatura / Additional Readings:

- P. Bak, How Nature Works: The Science of Self-Organized Criticality, Springer, 1996.
- M. Mitchell, An Introduction to Genetic Algorithms, The MIT Press, 1998.
- Novejši članki v Physical Review Letters, Nature, Science in drugih sorodnih revijah./ Recent articles in Physical Review Letters, Nature, Science and similar journals.

Cilji in kompetence:

- Študentje pridobijo teoretična in praktična znanja s področja modelov v fiziki.
- Pri laboratorijskih vajah samostojno pripravijo projekt in izračun enega modela.
- Seminarsko delo je namenjeno pripravi teoretične razlage modela

Objectives and competences:

- Students get theoretical and practical knowledge from the models in Physics
- Student prepares one model in the scope of the laboratory work
- Seminar work is designed for preparing theoretical justification of the model.

Predvideni študijski rezultati:

Znanje in razumevanje:

- Razume in uporabi različne fizikalne modele.
- Ustvari kompleksne fizikalne modele.
- Analizira fizikalne modele, jih reši in ovrednoti dobljene rezultate.

Prenosljive/ključne spretnosti in drugi atributi:

- Delo z modeli je prenosljivo na druga, nefizikalna področja, npr. ekonomijo.

Intended learning outcomes:

Knowledge and Understanding:

- The student understands and applies various physical models.
- The student creates complex physical models.
- The student analyses physical models, solves them and evaluates the obtained results.

Transferable/Key Skills and other attributes:

- Work with the models is transferable to non-physical fields, for example to economy.

Metode poučevanja in učenja:

Learning and teaching methods:

Razlaga, razgovor, študij primerov, problemsko učenje, laboratorijsko delo z računalniki.

Lecture, discussion, case studies, problem based learning, laboratory work with computers.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	Assessment:
sprotne naloge	35	coursework
seminarska naloga	35	seminar paper
ustni izpit	30	oral exam
<i>vsak del posebej mora biti pozitivno ocenjen, preden se lahko začne ocenjevanje naslednjega dela,</i>		<i>each individual part must be positively evaluated before the evaluation of the next part can begin</i>

Oblikovano: Pisava: Ne Krepko

Oblikovano: slovenščina

Reference nosilca / Lecturer's references:

- ZIDANŠEK, Aleksander, HÖLBL, Arbresha, RANJKESH SIAHKAL, Amid, CORDOYIANNIS, George, KUTNJAK, Zdravko, KRALJ, Samo. Impact of random-field-type disorder on nematic liquid crystalline structures. *The European physical journal. E., Soft matter*. 2022, vol. 45, no. 7, str. 63-1-63-12, ilustr. ISSN 1292-895X. DOI: 10.1140/epje/s10189-022-00217-y. [COBISS.SI-ID 116649731]
- VASUDEVAN, Aswathy, SHVALYA, Vasyl, KOŠIČEK, Martin, ZAVAŠNIK, Janez, JUROV, Andrea, SANTHOSH, Neelakandan Marath, ZIDANŠEK, Aleksander, CVELBAR, Uroš. From faceted nanoparticles to nanostructured Thin Film by Plasma-Jet Redox Reaction of Ionic Gold. *Journal of alloys and compounds*. [Print ed.]. Dec. 2022, vol. 928, [article no.] 167155, str. 1-11, ilustr. ISSN 0925-8388. DOI: 10.1016/j.jallcom.2022.167155. [COBISS.SI-ID 121112067]
- SHVALYA, Vasyl, MODIC, Martina, SKUBIC, Cene, NADIŽAR, Nejc, ZAVAŠNIK, Janez, VENGUST, Damjan, ZIDANŠEK, Aleksander, ROZMAN, Damjana, CVELBAR, Uroš, et al. Bacterial DNA recognition by SERS active plasma-coupled nanogold. *Nano letters*. Dec. 2022, vol. 22, iss. 23, str. 9757-9765, ilustr. ISSN 1530-6992. <https://repozitorij.uni-lj.si/lzpisGradiva.php?id=144312>, DOI: 10.1021/acs.nanolett.2c02835. [COBISS.SI-ID 127669763]
- ABINA, Andreja, PUC, Uroš, JAZBINŠEK, Mojca, ZIDANŠEK, Aleksander. Analytical gas sensing in the terahertz spectral range. *Micromachines*. 2023, vol. 14, str. 1-38, ilustr. ISSN 2072-666X. <https://www.mdpi.com/2072-666X/14/11/1987>, [Digitalna knjižnica Univerze v Mariboru – DKUM](#), DOI: doi.org/10.3390/mi14111987. [COBISS.SI-ID 170582019]
- ZID, Maha, PAL, Kaushik, HARKAI, Saša, ABINA, Andreja, KRALJ, Samo, ZIDANŠEK, Aleksander. Qualitatively and quantitatively different configurations of nematic–nanoparticle mixtures. *Nanomaterials*. [Online ed.]. 2024, vol. 14, issue 5, str. 1-16. ISSN 2079-4991. DOI: [10.3390/nano14050436](https://doi.org/10.3390/nano14050436). [COBISS.SI-ID 187069955]