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 2nd degree		1	**1**

Vrsta predmeta / Course type	obvezni/compulsory
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:	Aleksander Zidanšek

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.

Prerequisits:

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

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 nevronske mreže, veliki jezikovni modeli
- **Kvantni računalniki:** Shorov algoritem, Groverjev algoritem, BB84, Hadamardova vrata

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
- **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, 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.

Prenesljive/ključne spretnosti in drugi atributi:

- Delo z modeli je prenosljivo na druga, ne-fizikalna 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:

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

Learning and teaching methods:

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
vsak del posebej mora biti pozitivno ocenjen, preden se lahko začne ocenjevanje naslednjega dela		each individual part must be positively evaluated before the evaluation of the next part can begin

Reference nosilca / Lecturer's references:

1. 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]

2. 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]

3. 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/IzpisGradiva.php?id=144312, DOI: 10.1021/acs.nanolett.2c02835. [COBISS.SI-ID 127669763]

4. 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]

5. 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. [COBISS.SI-ID 187069955]