Univerza v Mariboru

Fakulteta za naravoslovje in matematiko

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	**Kompleksni sistemi**
Course title:	**Complex Systems**

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Fizika, 1. stopnja		**3**	**5**
Physics, 1st cycle		**3**	**5**

Vrsta predmeta / Course type Obvezni/Compulsory

Univerzitetna koda predmeta / University course code:

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje work	Druge oblike študija	Samost. delo Individ. work	ECTS
30		**15**			**75**	**4**

Nosilec predmeta / Lecturer: Samo Kralj

Jeziki / Languages:	**Predavanja / Lectures:**	slovenski/Slovenian
	Vaje / Tutorial:	slovenski/Slovenian

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**
Priporočljivo je predznanje klasične in moderne fizike. Vsaka izmed naštetih obveznosti v načinih ocenjevanja mora biti opravljena s pozitivno oceno.	Recommended is preknowledge of classical and modern physics. Each of the listed obligations in the assessment methods must be completed with a positive grade.

Vsebina: **Content (Syllabus outline):**

Definicija kompleksnosti kot vmesno stanje med redom in neredom. Enostavnost na subatomskem nivoju in kompleksnost na makroskopski skali.Naključje na mikroskopski skali in determinizem na makroskopski skali. Vzroki skalnega obnašanja.DNK in ompleksnost živih bitij, nastanek vzorcev.Granularni sistemi kot modelni sistemi tekočih, trdnih in celo kristalnih stanj. Kinetika bioloških sistemov: – sistemi metabolizma in transporta (shrambni modeli, modeli biokemijskih reakcij, farmakokinetski modeli) – modelni pristop h kompleksnim biološkim procesom (modeli razmnoževanja in interakcij, modeli rasti in delitve, evolucijski modeli, modeli neuronskih procesov) – difuzijski sistemi in oblikovanje vzorcev	Definition of complexity as a state between order and disorder.Simplicity on the subatomic scale and complexity on the macroscopic scale. Reasons behind scaling behaviour.DNA and complexity, onset of patterns in leaving creatures.Granular systems as model systems of fluids, solids and even crystal states. The kinetics of biological systems: - systems of metabolism and transport (compartmental analysis, models of biochemical reactions, pharmacokinetic models) - model approaches to some complex biological processes (models of propagation and ecological interactions, models of growth and differentiation, models of evolution, models of neuronal processes) - diffusion system and pattern growth

Temeljni literatura in viri / Readings:

- H. Sayama, Introduction to the Modeling and Analysis of Complex Systems (State University of New York at Binghamton, Binghamton, NY, 2025); prosto dostopno: https://open.umn.edu/opentextbooks/textbooks/introduction-to-the-modeling-and-analysis-of-complex-systems

Dodatna literatura / Additional readings:

- M. Mitchell Waldrop, Complexity-The-Emerging Science at Edge of Order and Chaos, Touchstone, New York, 1992. (Free Download, Borrow, and Streaming : Internet Archive)
- Geoffrey B. West, Scale: The Universal Laws of Growth, Innovation, Sustainability, and the Pace of Life in Organisms, Cities, Economies, and Companies, Penguin Press, 2018.
- Steven Strogatz, Sync: The Emerging Science of Spontaneous Order, Grand Central Publishing, 2003.
- R. Glaser, Biophysics, Springer Verlag, Berlin, 1996, prosto dostopno: https://link.springer.com/book/10.1007/978-3-642-25212-9
- H. Haken, Synergetics. An Introduction (2. izdaja), Springer Verlag, New York, 1978.
- P.G. de Gennes, Scaling Concepts in Polymer Physics, Cornell University Press, Itaca 1979
- A.J. Lichtenberg, Regular and Stohastic Motion, Springer Verlag, Heidelberg, 1983
- Članki v/ Papers in Science, Nature, Scientific American.

Cilji in kompetence:	**Objectives and competences:**

Študenti usvojijo temeljna teoretična znanja s področja kompleksnih sistemov in jih znajo uporabiti pri reševanju ustreznih problemov z rabo matematičnih orodij.	Students acquire basic theoretical knowledge in complex systems and are able to use the knowledge to solve problems with the use of mathematical tools.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanje in razumevanje: Po uspešno zaključeni učni enoti bodo študenti zmožni: - uporabiti enostavne nelinearne enačbe za demonstracijo ključnih nelinearnih primerov v naravi; - opisati osnovne lastnosti fraktalnih in kaotičnih sistemov; - napovedati kvalitativne lastnosti sistema v odvisnosti od simetrije sestavnih gradnikov sistema. **Prenesljive/ključne spretnosti in drugi atributi:** Razumevanje osnovnih procesov v naravi, ki vodijo do kompleksnih obnašanj in celosten pristop k reševanju problemov.	**Knowledge and understanding:** On completion of this course students will be able to: - use simple nonlinear equations to demonstrate key nonlinear commonly observed features; - describe basic properties of fractal and chaotic systems; - description of qualitative behaviour of system as a function of symmetry. **Transferable/Key Skills and other attributes:** Understanding of basic processes in the nature giving rise to complexity and gained global approach to solving problems.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja in eksperimentalna predavanja (teoretičen uvod v problematiko z razlago in razgovorom, numerično reševanje posameznih problemov, demonstracijski poskusi pri predavanjih), teoretične vaje (delo s tekstom, metoda pisnih in grafičnih del, uporaba simulacij) elementi obrnjenega poučevanja Poučevanje in učenje potekata z didaktično uporabo informacijsko-komunikacijske tehnologije	Lectures and experimental lectures (theoretical introduction by explanation and discussion, numerical solving of specific problems, demonstration experiments during lectures) theoretical excercises (work with text, work with graphic elements, use of simulations) elements of flipped learning Teaching and learning are done through the didactic use of ICT.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**

Pisni izpit Ustni izpit	**50** **50**	Pisni izpit Ustni izpit

Reference nosilca / Lecturer's references:

1) ČREŠNAR, Dejvid, ROŽIČ, Brigita, KUTNJAK, Zdravko, KRALJ, Samo. Theoretical and experimental study of elastocaloric responses in liquid crystalline elastomers. *Journal of molecular liquids*. [Online ed.]. Nov. 2024, vol. 413, [article no.] 126058, str. 1-14, ilustr. ISSN 1873-3166. DOI: 10.1016/j.molliq.2024.126058. [COBISS.SI-ID 208151299],
2) SINGH, Varun, PAL, Kaushik, SINGH WATTS, Sarangat, ASTHANA, Nidhi, ALI KHAN, Azmat, FATIMA, Sabiha, JELEN, Andreja, KRALJ, Samo. Graphene oxide dispersed rose-petals based green chemistry synthesis of hybrid composite for novel spectroscopic applications. *Journal of molecular liquids*. [Print ed.]. 2024, vol. 414, art. 126166, 16 str. ISSN 0167-7322. DOI: 10.1016/j.molliq.2024.126166. [COBISS.SI-ID 211786243]
3) SVETEC, Milan, HARKAI, Saša, PAL, Kaushik, KRALJ, Samo. Twist disclinations mediated transformations in confined nematic liquid crystals. *Journal of molecular liquids*. [Online ed.]. 15 Nov. 2024, part b, [article no.] 126138, 10 str., ilustr. ISSN 1873-3166. DOI: 10.1016/j.molliq.2024.126138. [COBISS.SI-ID 214061315]
4) JELEN, Andreja, ZID, Maha, PAL, Kaushik, RENUKA, Remya Rajan, ČREŠNAR, Dejvid, KRALJ, Samo. Nano and micro-structural complexity of nematic liquid crystal configurations. *Journal of molecular liquids*. [Print ed.]. 2024, vol. 415, part a, [article no.] 126275, 9 str., ilustr. ISSN 0167-7322. DOI: 10.1016/j.molliq.2024.126275, DOI: 20.500.12556/DKUM-91264. [COBISS.SI-ID 217792259]
5) HÖLBL, Arbresha, PAL, Kaushik, AHMAD, Irfan, ASIRI, Hatem Mohammed A, KRALJ, Samo. Colloid and nanoparticle-driven phase behavior in weakly perturbed nematic liquid crystals. *Journal of molecular structure*. [Print ed.]. Jul. 2024, vol. 1307, [article no.] 138002, 8 str. ISSN 0022-2860. DOI: 10.1016/j.molstruc.2024.138002. [COBISS.SI-ID 194451715]